

# THE PROCEEDINGS OF THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

## Series A. GENERAL ENTOMOLOGY

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# THE INTERNAL ANATOMY OF *CORIOXENOS ANTESTIAE* BLAIR (STREPSIPTERA)

By B. COOPER, B.Sc., A.R.C.S.

Communicated by T. W. KIRKPATRICK, F.R.E.S.

## 1. INTRODUCTION.

*Corioxenos antestiae* is an endoparasite of *Antestia* spp. (PENTATOMIDAE) the "Variegated Coffee-bug," which is one of the major pests of *Coffea arabica* in East Africa. The parasite has recently been described by Blair (1936), and an account of its bionomics and host-relations has been published by Kirkpatrick (1937).

The present work was carried out at the East African Agricultural Research Station, Amani, Tanganyika, between March and September 1936, under the direction of Mr. Kirkpatrick, Entomologist to the Station. Valuable help and advice were also received from Mr. L. R. Doughty, in particular with regard to sectioning and staining technique.

Material was obtained from Mr. Kirkpatrick, and also collected from coffee estates in the Kilimanjaro area.

### *Technique.*

The *Antestia* were dissected in 1% sodium chloride solution and the parasites fixed by immersion whilst still alive in one of the following:—

1. Bouin's fixative. 2. Picrochloracetic fixative. 3. A combination of the above two, with the following formula:—

Chloroform, 6.5 c.c.; Glacial acetic acid, 5.5 c.c.; Formalin (40%), 12 c.c.; Alcohol (90%), 50 c.c.; Water, 15 c.c.; Picric acid (dry), 0.3 g.

On the whole, fixative No. 3 was the best all round, but No. 2 gave good results with the middle stages. No. 1 was unreliable, causing considerable shrinkage of delicate tissues.

Fixatives (1) and (2) above, as well as stains shortly to be referred to, were prepared according to formulae given by Eltringham (1930).

Fixation was carried out for between 18 and 26 hours, followed by washing in several changes of alcohol of the same strength as the fixative, and 1 hour in each of ascending alcoholic grades up to absolute—(except that in the case of material fixed in Bouin, 24 hours were allowed in 70% alcohol). Material was then taken through an absolute alcohol-cedarwood oil diffusion gradient, and stored in cedarwood oil until required for embedding or other treatment.

Material was infiltrated in three changes of 63° C. paraffin wax,  $\frac{1}{4}$  hour being allowed in each of the first two baths and 1 to 1½ hours in the final bath, according to size. For the larger specimens, such as adult fertilised females and adult males and pupae, up to 3 hours were required in the final bath to effect complete penetration if the material had been stored in cedarwood oil for more than a few days.





FIG. 1.—Photomicrograph of longitudinal section of part of abdomen of parturient female, showing two triungulins escaping by a genital canal.  $\times 140$ .

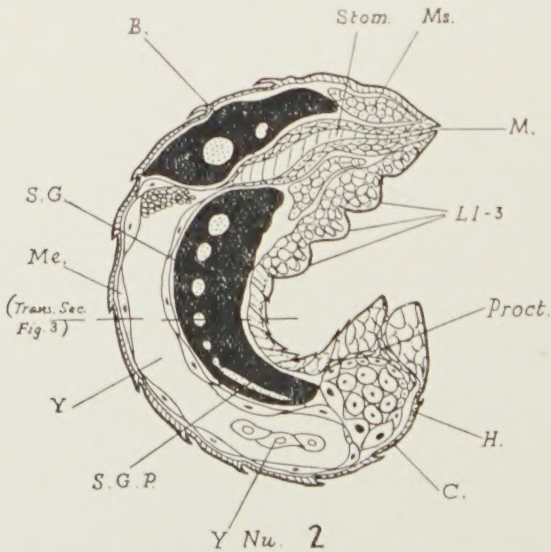
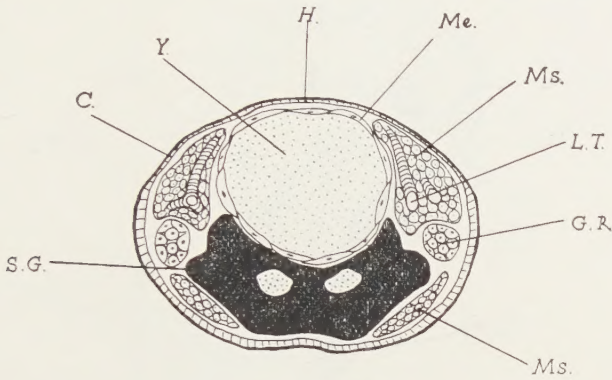


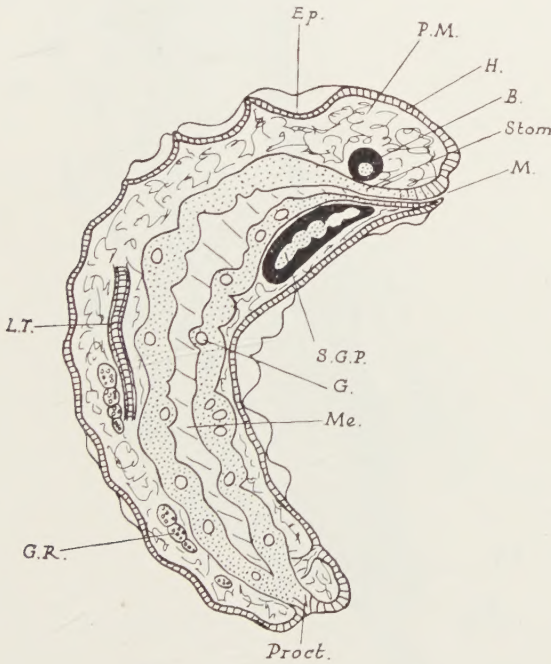
FIG. 2.—Longitudinal section of nearly mature embryo.  $\times 314$ .

Sectioning was done on a Cambridge rocking microtome. Under the prevailing conditions it was found that sections of less thickness than  $8\mu$  could not be cut without shortening of the ribbon, due to melting at the point of impact.



3

FIG. 3.—Transverse section of nearly mature embryo (as indicated in Fig. 2).  
× 666.



4

FIG. 4.—Longitudinal section of larva of 1st parasitic instar. × 105.

With waxes of lower melting point this effect was even more pronounced. The air temperature was between  $70^{\circ}$  and  $75^{\circ}$  F.

Sections were stained in borax carmine (30% alcoholic) for three days,

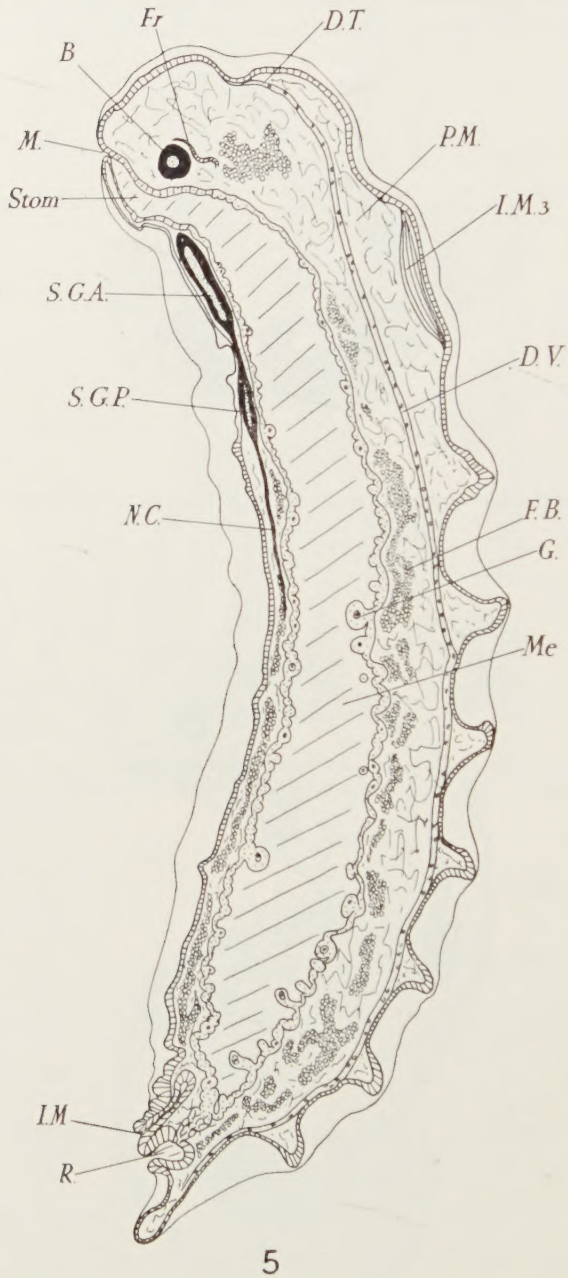


FIG. 5.—Longitudinal section of male larva of 4th parasitic instar.  $\times 45$ .



differentiated in alcohol for 2 hours, washed in water, and counterstained in picro-nigrosin for 30 seconds. For the proper differentiation of the counter-stain it was found best to leave the sections in 90% alcohol for at least 10 minutes.



6

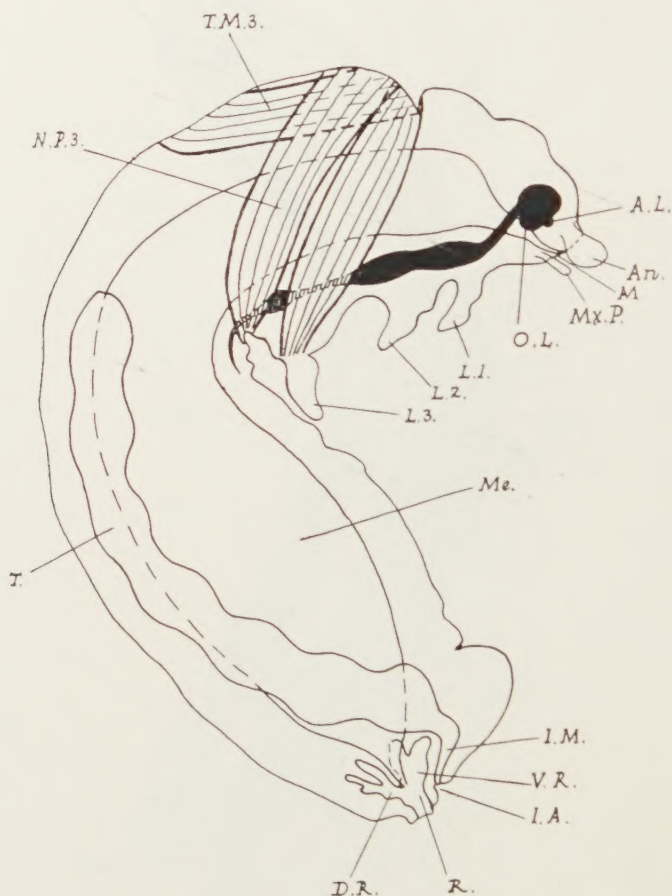
FIG. 6.—Longitudinal section of female larva of 4th parasitic instar.  $\times 55$ .

Whole mounts were most successfully prepared by fixation in fixative No. 3, dehydration, passage into cedarwood oil, and mounting in Gurr's neutral mounting medium. Internal structure could be seen quite well without staining, the yellow coloration from the fixative showing distinct degrees of differentiation.

Photographs were obtained by means of a simple projection camera placed above the eye-piece of the microscope.

## 2. INTEGUMENT.

The integument is uniformly thin, except for a region of thickened dermis on the cephalothoracic segments of the adult female, in the dorsal prominences,



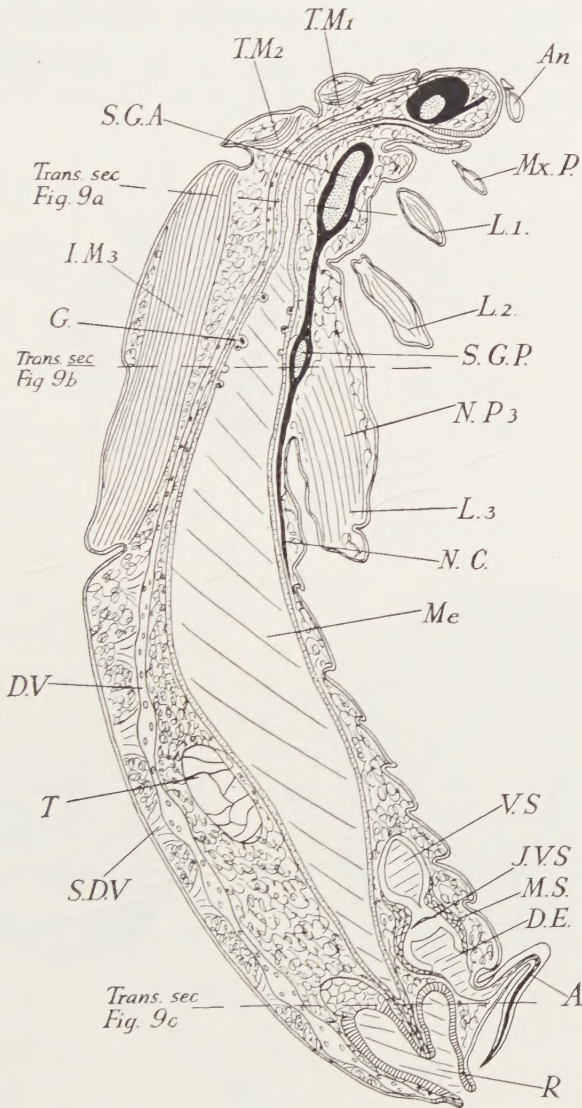
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FIG. 7.—Male pupa, in early stage of development (from a whole mount).  $\times 30$ .

and in the invaginations of the genital canals, male genital aperture, stomodaeum, and proctodaeum. Generally the hypodermis consists of a single layer of flattened cells, but in some parts it may consist of two layers of irregularly shaped cells. In the adult female especially, and in the dorsal prominences, hypodermal processes connect with the dermis. A thin basement membrane is present (fig. 16). In the immature stages and the female no cuticular processes appear to be present, but in the adult male the entire body is covered



with microtrichia, with the exceptions of the eyes and inter-segmental membranes. There are macrotrichia on the antennae of the adult male (fig. 20).



8

FIG. 8.—Longitudinal section of male pupa, at about the middle of the stadium.  $\times 37$ .

The epidermis of the free-living larva and of the adult male is sclerotised all over. The larval spiracles become sclerotised at the 5th parasitic instar; at extrusion at the 6th instar the head and thoracic segments become strongly sclerotised. In the adult female the ventral epidermis of the four segments on which the genital canals open becomes sclerotised (fig. 16).

## 3. BODY CAVITY.

The haemocoel is filled with closely packed cells of about  $3.5\ \mu$  in diameter, taking a blue-green stain. These cells contain numerous darker staining bodies, but no nuclei are discernible.

Fixation of this tissue without shrinkage was extremely difficult. For convenience this tissue will be referred to as the primitive mesoderm (figs. 4, 5, P.M.).

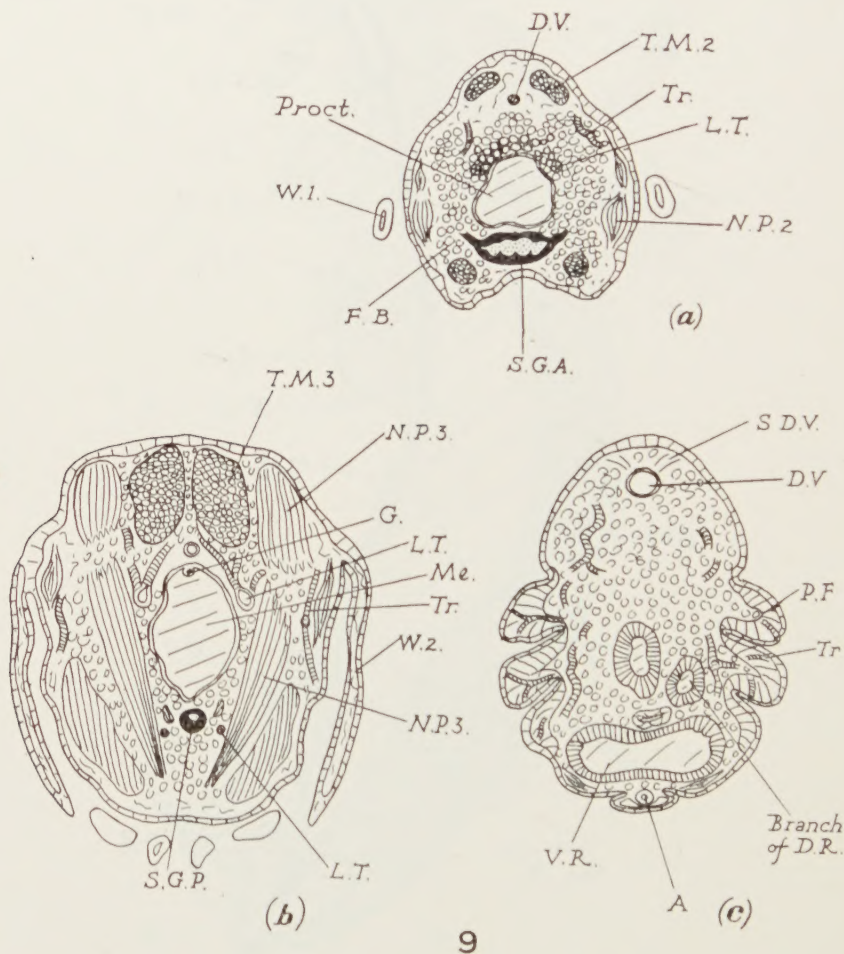


FIG. 9, *a*, *b*, *c*.—Transverse sections of male pupa (as indicated in Fig. 8).  $\times 50$ .

## 4. ALIMENTARY CANAL.

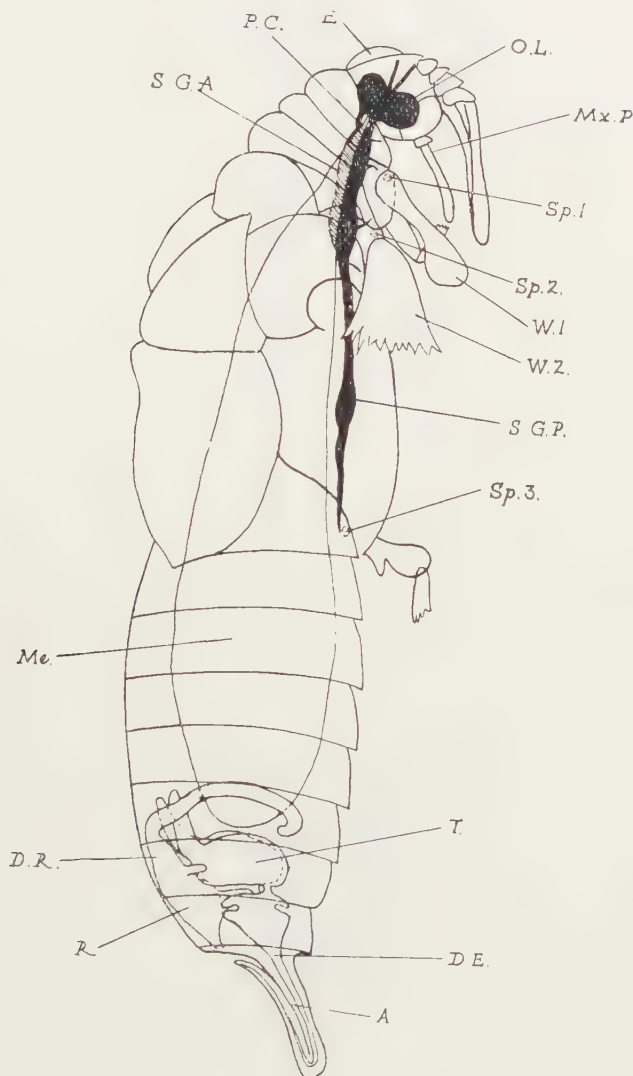
In the nearly mature embryo the alimentary canal is straight and clearly divisible into the following regions:—

1. The stomodaeum is long, open anteriorly and joining the cells of the mesenteron which surround the yolk mass. Near its middle it is wide, but there is no clear division into pharynx and oesophagus (fig. 2, Stom.).



2. The mesenteron consists of thin-walled flat cells with conspicuous nuclei, which surround the yolk mass (fig. 2, Me.). A posterior mass of cells of similar appearance is probably also mesenteric.

3. The proctodaeal invagination consists of cells quite dissimilar to those of the mesenteron, the nuclei not being at all conspicuous (fig. 2, Proct.).



10

FIG. 10.—Adult male, just before emergence from pupa (from a whole mount).  $\times 30$ .

In the free-living or triungulin larva the stomodaeal region is elongated owing to the oesophageal ganglia being placed half-way along the body (fig. 2).

Posterior to the oesophageal ganglia is a distinct swelling of the mesenteron, whilst the same mass of cells lies between the mesenteron and the proctodaeal invagination.

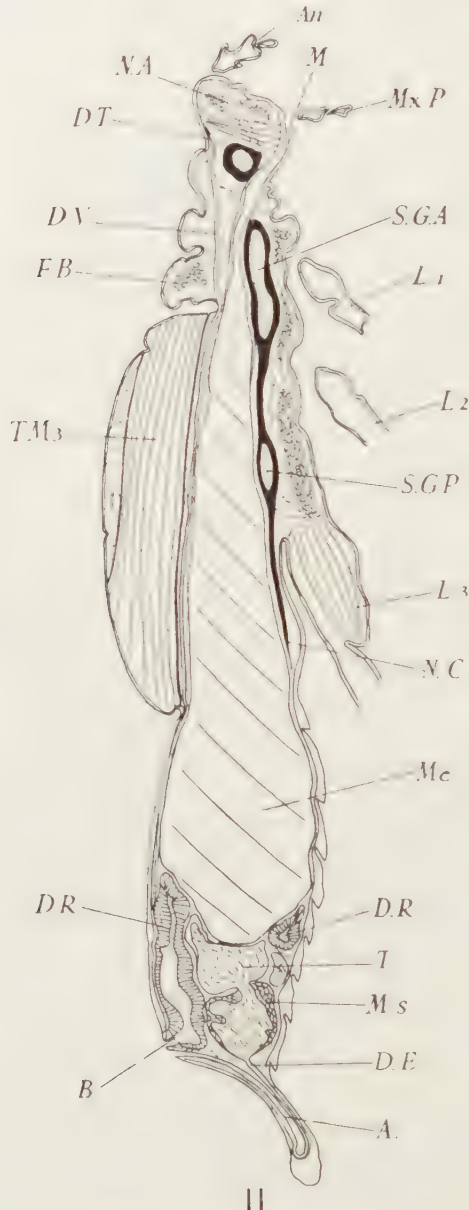


FIG. 11.—Longitudinal section of adult male.  $\times 37$ .

In the 1st parasitic instar, especially at the end of the stadium, the ganglia are comparatively much further forward (fig. 4). There does not appear to be any distinct pharynx; posteriorly to the ganglia and extending with a wide



lumen practically to the posterior extremity is the mesenteron, with cells containing large nuclei projecting into its lumen (figs. 4 and 18, G.). The proctodaeal invagination is comparatively small, and there is no connection between the mesenteric and proctodaeal lumina at this or at any other stage



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FIG. 12.—Longitudinal section of mature unfertilized female.  $\times 45$ .

throughout the life history. Until the completion of larval growth there is little change in the proportions of the alimentary canal in the female; the cells with large nuclei become very prominent (fig. 6). At about the 4th instar in the male the proctodaeal invagination enlarges, forming a definite rectum with a constricted aperture (fig. 5, R.). At a slightly later stage (probably

during the 5th instar) two hollow tubular outgrowths appear on the rectum, ventrally and dorsally near its junction with the mesenteron. During the pupal stage each of these outgrowths develops two branches (fig. 7, D.R. and V.R.). In the adult male the dorsal outgrowth develops strongly and one branch passes laterally and round the ventral side in a semi-circle (fig. 10). The cells composing these outgrowths do not in any way resemble the cells lining Malpighian tubules, as described by Veneziani (quoted by Imms (1924)) in Coleopterous larvae. No pore-canal or canaliculi are visible; large vacuoles are present and the number of cells seen in cross-section to line the lumen is



## 13

FIG. 13.—Longitudinal sections of stages in the development of the female genital canals. (a) 4th parasitic instar. (b) 5th parasitic instar. (c) 6th parasitic instar. (d) Mature female.  $\times 106$ .

about a hundred. It does not, therefore, seem likely that these outgrowths represent Malpighian tubules. Pierce (1909) suggests that the Malpighian tubules in Strepsiptera are doubtfully represented by small papillae. If these papillae correspond to the proctodaeal outgrowths in this species, then it seems most probable that both are in the nature of rectal caeca.

In both sexes, during the 6th parasitic instar, practically all the large cells projecting into the lumen migrate into it and are either absorbed or else degenerate. In the mature female none is present, the mesenteron being thin and sac-like (fig. 12, Me.), with flat pavement cells and small nuclei.

During the 6th instar the posterior extremity of the mesenteron becomes elongated, and joined to the integument only by a thread of cells. This thread



breaks when maturity is reached, and the developing eggs after fertilisation squeeze the mesenteron further and further forward, flattening it by their pressure.

In the later stages of the male pupa the posterior part of the gut undergoes a similar elongation, and in the adult male connection has been broken; the mesenteron becomes extremely thin-walled and membranous, filling practically the whole of the cavity of the abdomen anterior to the genital organs and rectum (fig. 11, Me.).



FIG. 14.—Photomicrograph of transverse section through eye of adult male.  $\times 235$ .

In both the adult female and the pupal stages of the male the cavity of the mesenteron is often filled with faecal matter. This is particularly noticeable in females that have found no room to be extruded from their host.

##### 5. NERVOUS SYSTEM.

The nervous system is well seen in the nearly mature embryo. The para-oesophageal connectives are thick, forming a very narrow lumen for the passage of the oesophagus. In the sub-oesophageal nerve mass six distinct ganglionic masses are discernible; posteriorly a long fused mass of ganglia is present, which probably comprises all the abdominal ganglia (fig. 2).

The condition in the free-living larva remains similar; in the 1st parasitic instar and later stages only four separate ganglia are seen anteriorly, and a fused ganglionic mass is present posteriorly.

In the 2nd parasitic instar a single nerve cord is visible, extending ventrally along the whole length of the body; this later shortens considerably in both sexes (figs. 5 and 6, N.C.).

At about the 3rd parasitic instar in both sexes a distinct constriction becomes visible in the fused posterior ganglia of the sub-oesophageal nerve mass. This never develops greatly in the female, but in the 4th parasitic instar of the male part of the posterior mass of ganglia has become separated from the main sub-oesophageal nerve mass, to which it is joined by a short cord (fig. 5, S.G.A. and S.G.P.). These two masses become rather further separated in the later stages.

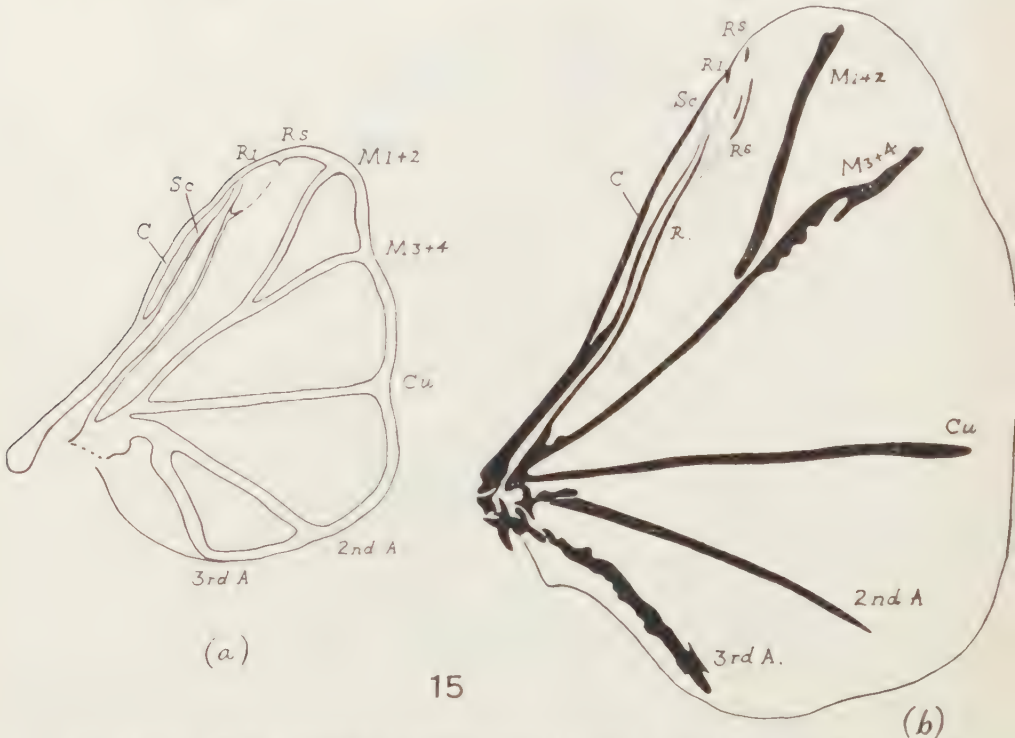


FIG. 15.—(a) Wing of male, as it appears about half-way through pupal stadium.  $\times 50$ .  
(b) Wing of adult male.  $\times 30$ .

The brain never attains any great size in the female; at maturity the whole nervous system appears to degenerate, since it shrinks to approximately half the size it was at the 4th parasitic instar (fig. 12). In the adult male the optic lobes and antennary lobes comprise a great part of the bulk of the brain (figs. 7 and 10, O.L. and A.L.). Prominent nerves pass forward to the antennae from near the middle line (fig. 11, N.A.). Near the ventral junction of the para-oesophageal connectives, nerves pass to the first pair of legs and to the pseudo-halteres or rudimentary mesothoracic wings. The nerves to the metathoracic wings and to the 2nd and 3rd pairs of legs are also derived from the anterior division of the sub-oesophageal nerve mass.



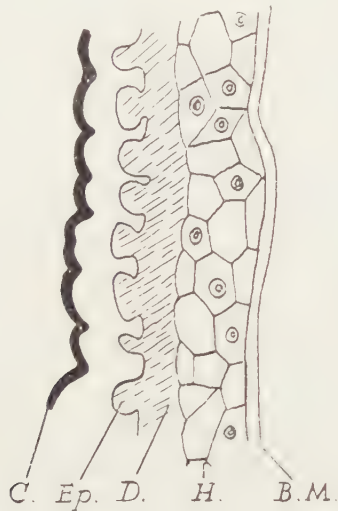
# 6. SENSE ORGANS.

*Sensillae.* Two different kinds of sensillae are present on the adult male :—

1. On the elongated extremities of the last three antennal segments are globe-like sensillae of unknown function (fig. 20). These are surrounded by groups of macrotrichia.

2. On the distal segments of the maxillary palps there are true trichoid sensillae, probably tactile, in fair numbers. Elsewhere are only a few trichoid sensillae scattered over the body.

*The Eye.* In the adult male the eye is apparently of the compound type, being composed of about fifty units innervated by the optic lobe. Areas



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FIG. 16.—Section through integument of adult female, in sclerotised ventral region.  
× 1300.

between individual facets are pigmented, the facets themselves being strongly convex and transparent (fig. 14). If the eye is really compound, it must be of the pseudocone type, since the lens is formed by a thickening of the cornea (fig. 19, Le.). In a study of the developing pupa an invagination of hypodermal cells is seen. These number about forty-five and secrete the cornea and lens combined. In the later stages these cells acquire a great number of pigment granules and become connected to endings of nerve-cells which pass through apertures in the fenestrated membrane. Internally the optic lobe is divided clearly into periopticon, epipticon and opticon (fig. 14). No rhabdoms can be distinguished in the eye units. Strohm (quoted by Snodgrass (1935)) suggested that the so-called compound eye in Strepsiptera is really made up of a collection of ocelli, not ommatidia. The units here described certainly seem to correspond to simple ocelli rather than to ommatidia.

## 7. CIRCULATORY SYSTEM.

The circulatory system is extremely simple, consisting of a single median dorsal vessel. This is well seen in the instars after the 3rd, in both sexes (figs. 5 and 6, D.V.). In the female of the 4th parasitic instar it is closely associated with the dorsal prominences, and is discernible as far back as the last of these. In the mature male it becomes difficult to make out in the abdominal region, but is clearly visible in the thoracic and head segments. Anteriorly, in both sexes, the vessel terminates narrowly at about the level of the brain (figs. 5, 6 and 8, D.T.). In the developing pupa the abdominal part of the dorsal vessel is very well developed, eight distinct chambers being visible (fig. 9).

An anteriorly-directed pulsating movement is easily seen in the living animal.

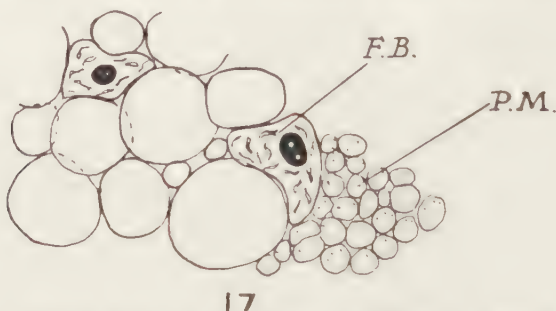


FIG. 17.—Section through fat-body and primitive mesoderm, showing vacuolated and nucleated cells of the fat-body.  $\times 1300$ .

## 8. RESPIRATORY SYSTEM.

The respiratory system can clearly be made out in the nearly mature embryo. It consists of two lateral tracheal trunks opening by spiracles on the 3rd thoracic segment (fig. 3, L.T.).

During the larval instars this arrangement persists, two main lateral trunks passing posteriorly from the region of the spiracle on either side; anteriorly, there is one trunk on each side, branching and supplying the anterior segments. Both posteriorly and anteriorly to the spiracle numerous branches and transverse commissures are visible.

At the 5th parasitic instar in both sexes the spiracular openings become sclerotised. At the pupal ecdysis in the male the cephalothoracic covering is thrown off, together with the sclerotised lining of the spiracles. The condition in the adult male is different, there being spiracles on the meso- and metathorax, as well as on the 1st abdominal segment; no other abdominal spiracles can be made out (fig. 10, Sp.). Otherwise the arrangement is similar to that obtaining in the earlier stages; the original metathoracic spiracle continues to function; the mesothoracic spiracle can be seen developing early in the pupal stadium.

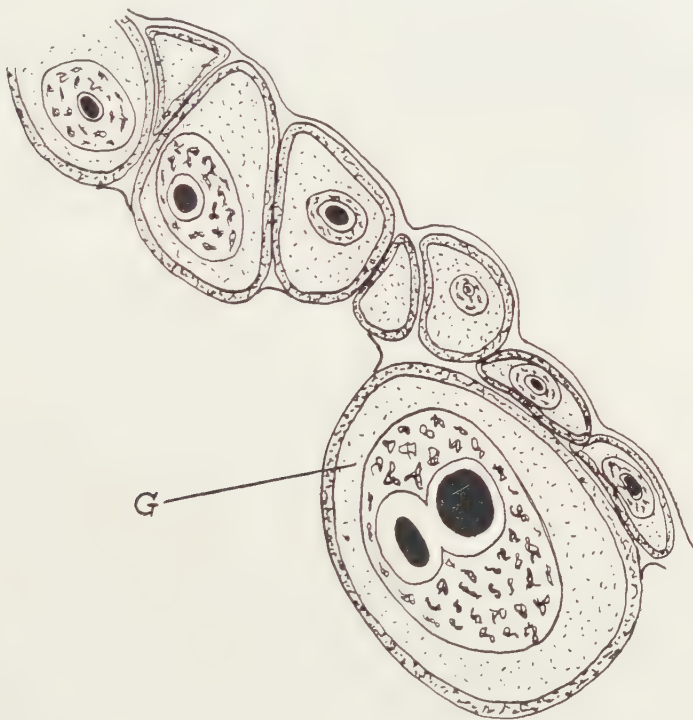
In the adult female the original spiracle continues to function and no others are formed. The posterior tracheal branches ramify greatly, filling the interstices of the body cavity between the eggs.

In the male pupa peculiar longitudinal folds of the pleura can be seen in transverse section. The hypodermis is not modified, but large cells with

cytoplasmic content staining green with picro-nigrosin lie internally. In this region the tracheae ramify considerably, sending small branches in amongst these green-staining cells.

### 9. EXCRETORY.

No definite excretory organs are present. It has been pointed out already that the outgrowths from the rectum are probably in the nature of rectal caeca, since their structure does not agree with that of Malpighian tubules.



18

FIG. 18.—Section through mesenteron of 4th parasitic instar, showing one of the cells with large nuclei projecting into lumen.  $\times 470$ .

*Fat-Body.* This is not present until about the 2nd or 3rd parasitic instar. It originates laterally from two rows of cell-clusters on either side, attached to the body-wall of the abdominal segments 2-8. Branching strings of vacuolated cells, interspersed with a few nucleated cells, are given off, tending to lie longitudinally in strings (figs. 5, 6, 17, F.B.). By about the 4th instar these strings begin to fill practically the whole body-cavity, the tissue previously referred to as the primitive mesoderm is now confined into comparatively small spaces, particularly in the anterior segments. The nucleated cells of the fat-body continue to produce more vacuolated cells, the greatest development being reached in the pupal stage. In the adult the fat-body has diminished very considerably; the primitive mesoderm, or possibly a secondarily derived

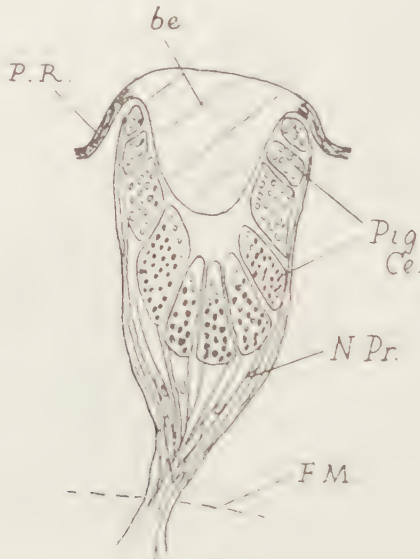


but similar tissue, again fills large parts of the body-cavity. No proximal and distal layers of the fat-body can be distinguished.

*Other Cells of Possible Excretory Functions.*

In females of the 4th and later parasitic instars groups of peculiar cells are situated both dorsally and posteriorly, and elsewhere irregularly distributed.

Owing to the fact that some of these cells are binucleate, they may quite probably represent the nephrocytes of other larvae. The only other tissue in any other stage observed to stain similarly is that lining the abdominal pleural folds in the male pupa (fig. 9, *c*, P.F.). In each of these tissues the cell cytoplasm stains green with picro-nigrosin and the nucleus takes up borax carmalum strongly: the shapes of the cells in the two tissues are, however, dissimilar.



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FIG. 19.—Longitudinal section through one unit of eye of adult male.  $\times 470$ .

10. REPRODUCTIVE SYSTEM.

The reproductive organs can be seen in the maturing embryo, lying laterally (fig. 3, G.R.).

In the 1st parasitic instar the sexes are still indistinguishable, the lateral organs join ventrally in front of the anus. During the 2nd instar the organs break up into spherical masses in the female, whilst in the male they remain compact. By the 3rd instar the posterior junction of the male organs is connected to a ventral epidermal invagination, which is the rudiment of the future genital aperture (fig. 5, I.M.).

The development of the genital organs will be followed separately in the two sexes.

*Female.* By the 4th instar the spherical cell masses previously separated off have developed an inner oocyte lying somewhat peripherally, about fifty nutrient cells surrounding the oocyte, and a peripheral envelope of flattened

cells. Thus it will be seen that each of these cell masses represents one follicle of an ovariole.

In the mature female the nutrient cells have no staining nuclei and the whole follicle has grown considerably (fig. 21, *b*). The three polar bodies, which are small, are cast off at the end of the 6th instar, remaining close to the egg.

The break-up of the genital rudiments in the female is not complete, follicles sometimes tending to form aggregates of two, three or four, being pressed closely together. At maturity the envelope cells between the separate follicles often tend to break down, causing the follicle clusters to be surrounded by one envelope. This, however, can always be seen to be divided; each oocyte thus enclosed produces only one embryo (fig. 21, *c*).

The four unpaired genital canals open ventrally on abdominal segments 3-6. They originate at about the 3rd instar as thickenings of the hypoderm, which by the 4th instar have been invaginated a small amount; mesodermal cells become associated with the invaginations (fig. 13, *a*). By the 5th instar elongation is taking place and a complete layer of mesodermal cells surrounds



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FIG. 20.—One of the sensillae on the extremities of the last three antennal segments of the adult male.  $\times 1300$ .

the invaginated sac (fig. 13, *b*). During the 6th instar further growth occurs, the end of the sac being composed of cells derived from the hypoderm only (fig. 13, *c*). At maturity the end of the sac evaginates, forming a funnel with a membrane closing its mouth (fig. 13, *d*). This membrane is broken by the escaping larvae (fig. 1). The larvae then work their way anteriorly, between the body of the parent and the epidermis which became detached at maturity. When they reach the cephalothoracic covering they escape by means of the aperture formed by the aedeagus of the male in copulation, or by the oral aperture.

At the time when larvae are beginning to escape, the maturer embryos are all concentrated peripherally. Since there is no trace of a spermatheca, it would appear that the retarded development of eggs near the centre cannot be due to late fertilisation. The reason may be that diffusion of nourishment from the body-cavity of the host to the centre of the egg-mass may take considerably longer than to the periphery. As larvae escape from the periphery when mature, the embryos a little further in will probably be pushed outwards by pressure of development, their development being correspondingly accelerated, whilst those nearest the centre continue to receive only a smaller amount of nourishment. In this way it may be possible to account for the observed period of production of larvae by the parent.

*Male.* Growth of the male organs continues until the pupal stage is reached, when meiosis takes place. Spermatozoa are visible by the time pigmentation of the eyes begins. The adult spermatozoa have lanceolate heads and long flagellae, their average length is  $100\ \mu$  (fig. 21, *a*).

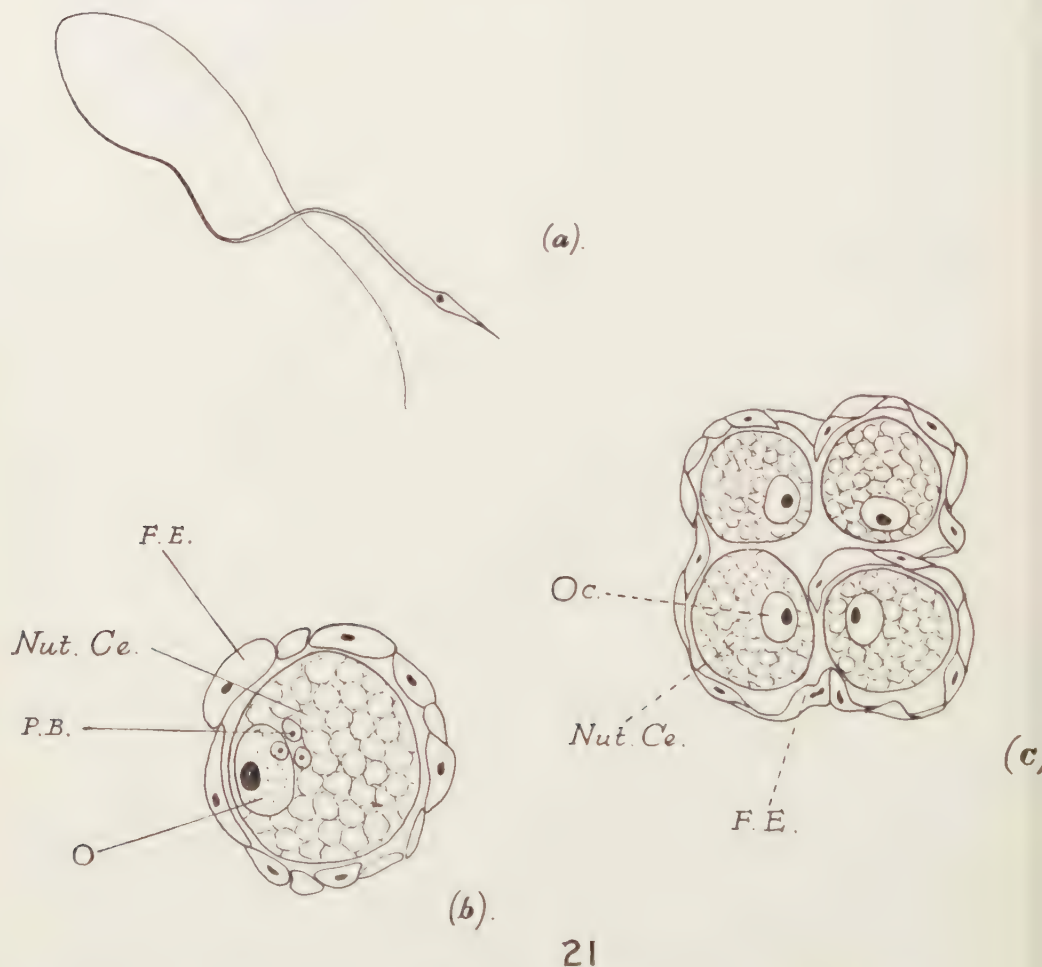


FIG. 21.—(a) Spermatozoon.  $\times 1300$ . (b) Mature egg-follicle.  $\times 470$ . (c) Four immature egg-follicles, of which the envelopes have coalesced.  $\times 470$ .

By the 4th instar the genital opening has become well invaginated (fig. 5, I.M.), the lumen is open to the exterior, and the invaginated mass is connected with the two lateral testis rudiments.

In the early pupa the testis rudiments exhibit a segmented appearance, being slightly constricted into 6 divisions (fig. 7, T.). The paired vesiculae seminales are sac-like and continuous with the testis rudiments, their lumina being connected transversely across the anterior end of the invagination of the genital opening (fig. 8, V.S., J.V.S.). Before maturity, however, no direct connection exists between the vesiculae seminales and the ejaculatory duct.



The ejaculatory duct has a muscular distension anteriorly and in the early pupa is seen to open directly to the exterior just ventrally to the anus (fig. 7). An invagination takes place later around the genital opening (fig. 7, I.A.), bending the middle part of the ejaculatory duct ventrally, the distal extremity continuing in the same position, but pointing dorsally (fig. 8, A.).

In the mature male the distal end of the ejaculatory duct comes to point antero-dorsally, being directed posteriorly by contraction of the muscles at the posterior articulation of the aedeagus (figs. 10 and 11, A.).



FIG. 22.—Glandular seta on tenth segment of triungulin larva.  $\times 866$ .

Towards maturity the testis masses become shorter and more sac-like, and come to lie in the distal one-third of the abdomen, which they nearly fill (figs. 10 and 11, T.).

## 11. ENDOSKELETON.

An endoskeleton is developed only in the thorax of the adult male.

1. Dorsal phragmata arise from the posterior borders of the pro-, meso-, and metanotum.

2. Ventrally, a median furca arises from the posterior border of the metasternum, sending a process anteriorly which terminates just behind the posterior division of the sub-oesophageal nerve mass.

Small median apodemes also arise from the pro- and mesosternum.

## 12. MUSCULAR AND LOCOMOTOR SYSTEMS.

In the free-living larva three pairs of thoracic legs are present, operated by posterior and anterior abductor and adductor muscles, attached to the dorsal body-wall somewhat laterally, and to the borders of the coxae.

In the larval stages of both sexes (except for special modifications in the male) muscles are present as follows:—

1. External circular muscles of body-wall.
2. Longitudinal muscles of body-wall.
3. Paired lateral dorso-ventral muscles of head and thoracic segments.
4. Opening muscles of mouth, attached dorsally and ventrally between the pharynx and body-wall.
5. Longitudinal tergal and sternal muscles placed dorsally and ventrally a little to the side of the mid-dorsal and mid-ventral lines.

In the adult female there is no modification of this primitive arrangement, but in the 4th male instar the tergal muscles of the metathorax begin to enlarge (fig. 5, T.M.3), as well as the lateral paired dorso-ventral muscles of this segment: the latter are rudiments of the notopedal muscles of the adult (fig. 7, N.P.). These, and the notopedal muscles of the pro- and metathorax, are the most prominent adult muscle rudiments visible by the beginning of the pupal stage.

The rudiments of the adult legs first appear in the 3rd instar of the male larva.

*The Wings (fig. 15).*

The wings show a slightly less degenerate type of venation than *Neostylops shannoni*, figured by Pierce (1918), but the homologies with this and other Strepsiptera figured by that author are obvious from a consideration of the pupal venation. No very early pupal wings were obtained, but the condition when all the veins have been formed and before wrinkling begins is shown in fig. 15, *a*. Wrinkling of the surface of the wings takes place about half-way through the pupal stage, the wings subsequently expand before the adult emerges. The detached veins which are said usually to lie between the radius and media in most species of Strepsiptera (Comstock, 1918) are seen in the pupa to be branches of these two veins. Thus the vein homologies are probably as indicated in fig. 15. The pupal wing tracheation was not, however, examined.

*The Dorsal Prominences (fig. 6, D.P.).*

These will be discussed under this heading, since they may possibly function as locomotor organs by churning movements in the body-fluid of the host. They are arranged intersegmentally on the abdomen, there being eight in either sex. They appear as dorsal intersegmental folds in the 2nd instar, and in later instars develop into conical spikes. The hypodermal lining is slightly thickened and the cavity inside is filled by the primitive mesoderm. The dorsal vessel passes ventrally but does not expand into the cavities. Tracheal branches pass into each cavity, ramifying amongst the hypoderm. The tergal muscles are attached laterally at the mid-line of the base of each prominence, and by their contraction would tend to flatten it slightly. In the mature fertilised female the prominences become comparatively small; there are certainly no organs in the adult male of which they are rudiments.

## 13. GLANDULAR ORGANS.

No accessory sex-glands have been observed. In the free-living larva the terminal setae of the 10th segment are connected with a pair of glandular bodies lying laterally on either side of the proctodaeum, composed of about twenty cells taking a bright crimson stain with borax carmine. Near the end of each seta is a swelling which contains a reservoir for the duct which passes through the seta and apparently opens near its extremity. The gland secretes a sticky substance which exudes from the seta (fig. 22).

## 14. SUMMARY.

The only other species of Strepsiptera of which the internal anatomy has been studied appear to be *Xenos rossii* and *Stylops melittae* (Nassonov, 1892-1893). It will be of interest to summarise the principal points in which the internal anatomy of *Corioxenos antestiae* resembles, or differs from, these species.

The alimentary canal is of similar arrangement in all three species. The presence of the large epithelial cells which project into the lumen of the mesenteron and are later absorbed is of interest. The rectal caeca, which are probably homologous with similar organs described by Nassonov, are only slightly different in *Corioxenos*; they arise separately in two places and each of them branches, whereas in the other species they arise as three in one row, branching and anastomosing, and later being joined to the proctodaeum by a single canal.

The nervous system in *Corioxenos* is more concentrated than in the other species. The abdominal ganglion is not separated from the sub-oesophageal nerve-mass in the female, and it is only separated by a short cord in the male.

The circulatory and respiratory systems appear to be similar in all three species.

The long tubes connecting the male sex-glands to the ejaculatory duct in *Stylops* and *Xenos* are absent in *Corioxenos*, their place being taken by more definite sac-like vesiculae seminales. The breaking down of the ovary at an early stage in all three species is remarkable, and would appear to be characteristic of the order.

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## LETTERING AND EXPLANATION OF FIGURES.

A.	Aedeagus.	Ne.	Nephrocytes.
A.L.	Antennary Lobe.	N.P. 1-3.	Notopedal muscles of pro-, meso- and metathorax.
An.	Antenna.	N.Pr.	Nerve processes.
B.	Brain.	Nu.	Nucleus.
B.M.	Basement membrane.	Nut.Ce.	Nutrient cells of oocyte.
C.	Sclerotised epidermis.	O.	Ovum.
D.	Dermis.	Oc.	Oocyte.
D.E.	Ductus ejaculatorius.	O.L.	Optic lobe.
D.P.	Dorsal prominence.	P.B.	Polar bodies.
D.R.	Dorsal rectal outgrowth.	P.C.	Para-oesophageal commissure.
D.T.	Anterior termination of dorsal vessel.	P.F.	Pleural folds.
D.V.	Dorsal vessel.	Pig.Ce.	Pigment cells.
E.	Eye.	P.M.	Primitive mesoderm.
Ep.	Epidermis.	P.R.	Pigmented regions between eye-facets.
F.	Separated follicle of ovary.	Proct.	Proctodaeum.
F.B.	Fat body.	Prot.	Protoplasm.
F.E.	Follicular envelope.	R.	Rectum.
F.M.	Fenestrated membrane.	S.D.V.	Suspensory filaments of dorsal vessel.
G.	Mesenteric cells projecting into lumen.	S.G.	Sub-oesophageal nerve-mass.
G.C. 1-4.	Genital canals.	S.G.A.	Anterior division of same.
G.R.	Genital rudiment.	S.G.P.	Posterior division of same.
H.	Hypodermis.	S.G.F.	Fused posterior ganglia of embryonic sub-oesophageal nerve mass.
I.A.	Invagination of aedeagus.	Sp. 1-3.	Spiracles of meso- and metathorax and first abdominal segment.
I.M.	Invagination of male genital aperture.	St.Gr.	Staining granules.
J.V.S.	Junction of vesiculae seminales.	Stom.	Stomodaeum.
L. 1-3.	Legs.	T.	Testis.
Le.	Lens.	T.M. 1-3.	Tergal muscles of pro-, meso- and metathorax.
L.T.	Lateral tracheal trunk.	Tr.	Tracheal branches.
M.	Mouth.	V.R.	Ventral rectal outgrowth.
Ma.	Macrotrichia.	V.S.	Vesicula seminalis.
Me.	Mesenteron.	W. 1 2.	Meso- and metathoracic wings.
Mi.	Microtrichia.	Y.	Yolk.
Ms.	Mesoderm.	Y.Nu.	Yolk nuclei.
M.S.	Muscular sheath of ductus ejaculatorius.		
Mx.P.	Maxillary palp.		
N.A.	Antennary nerve.		
N.C.	Posterior nerve cord.		

## BOOK NOTICE.

*Festschrift zum 60. Geburtstage.* von Prof. DR. EMBRIK STRAND. Vol. 1-2. 8vo. Riga, 1936-1937. Vol. 1, pp. 644, 19 pls., 105 figs.; Vol. 2, pp. 652, 37 pls., 118 figs.

These two volumes are an instalment of the *Festschrift* to be issued to mark Prof. Strand's sixtieth birthday. They contain "dem Jubilar gewidmete Arbeiten auslndischer Zoologen und Palaeontologen." Vol. 1 contains 51 papers by 49 authors, of which 28 deal with entomological subjects.

Vol. 2 contains 44 papers by 39 authors (some of whom also contributed to Vol. 1), of which 12 deal with entomological subjects.

The subject-matter of the papers ranges over the whole field of Zoology and extends to Palaeontology, and is mostly taxonomic in character.

The entomological papers in Vol. 1 deal with Lepidoptera 5, Coleoptera 4, Hymenoptera 2 and Diptera 1, and those in Vol. 2 with Coleoptera 13, Hymenoptera 6, Lepidoptera 4, other orders 5.

## THE CARDBOARD CELL METHOD FOR THE MOUNTING OF INSECTS AND THEIR PARTS

By B. JOBLING, F.R.E.S.

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Scientific Research, London.*)

THE cell method is generally used for mounting large specimens, when it is necessary to obtain a permanent microscopic preparation without any distortion of the form by pressure of the cover glass. The technique which is described here differs from others in the use of cardboard rings instead of those made of glass or metal. The latter do not vary very much in their height; they are usually too high and cannot be adjusted to the thickness of the specimen. The cardboard rings can be made of any thickness, and those which are too thick can easily be made thinner with a sharp penknife after they have been attached to the slides.

Many entomologists, who have seen my preparations, have asked me about the technique, which I describe in detail.

### THE PREPARATION OF THE RINGS.

For the preparation of the cardboard rings, it is necessary to have two steel punches, one of a narrow diameter to punch the middle hole and a wider one to cut the rings out of cardboard. These punches can be obtained from any good ironmongers. The size of the punches depends upon the size of the cover glasses which are intended to be used for mounting. For a  $\frac{3}{4}$ -inch cover glass one punch must be  $\frac{3}{8}$  inch in diameter and the other just a little broader than the cover glass.

The cardboard is selected according to the thickness of the specimens. It must be remembered that the ring should be the same thickness as the specimen which is intended to be mounted in it, because in a cell made with a thin ring the form of the specimen is usually distorted by the pressure of the cover glass, whereas in the thicker ring it may be too far from the cover glass and unsuitable for examination under a high magnification of the microscope, and it may also alter its position in the cell.

When the cardboard is selected, with the broad punch make as many circular indentations in it as are necessary for the number of rings required. After this, place the cardboard on the butt end of a block of wood, place the narrow punch exactly in the middle of the circular indentation and, using the hammer, punch the middle out. Next, cut the ring out with the broad punch. The circular indentation will show the exact position for this punch on the cardboard. Never punch the outer circle first and then the hole in it, because this will always split the ring.

### THE ATTACHMENT OF THE RINGS TO THE SLIDES.

Before attaching the rings to the slides all air must be removed from them, by placing them in slightly warmed xylol, or in 95% spirit if the specimens are intended to be mounted in euparal. From xylol or spirit they must be transferred respectively to a very weak solution of Canada balsam, or euparal.

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For the arrangement of the rings in the middle of the slides it is best to use the apparatus shown in figure 1, D. This is made of a piece of board covered with paper, on which is drawn the outline of the slide with the circle in the middle. The circle must be of the same diameter as that of the rings, or just a little larger. Along the two sides of the outer drawing are attached two strips of cardboard, or two narrow pieces of thin board which make the frame (f.). When the slide is placed in the frame, the circle will show through the glass the correct position for the ring.

Before arranging the rings on the slide, they must be flattened by pressure between two perfectly flat pieces of wood. This will also remove from them any excess of Canada balsam, or euparal. Place the ring on the slide with forceps and exactly in the middle of it place four or five drops of Canada balsam, or euparal. The mounting medium must be of such a thickness that it will spread evenly towards the sides of the ring and form the cavity as shown in figure 1, A. The mounting medium must not be dropped to one side of the ring, because in that case it will accumulate at this point on the outer side of the ring and form an asymmetric cell.

The slides with the attached rings must be stored in a dust-proof, warm place, and kept there until the Canada balsam, or euparal, is perfectly dry. The process can be considerably shortened if, on the second or third day after mounting the rings, the slides are placed on a hot plate, or on top of a paraffin oven. It is not advisable to place them in a hot place immediately after the introduction of the mounting medium, because this will become too liquid and spread over the slide. The cells must not be used until they are perfectly dry.

#### MOUNTING THE SPECIMENS.

Fill the cell with very thick Canada balsam or euparal, as shown in figure 1, B. Introduce the specimen in the middle, using two dissecting needles wetted in xylol, or 95% spirit if the specimen is to be mounted in euparal. Push the specimen to the bottom of the cell, where the slightly dissolved mounting medium, with which the ring was attached to the slide, will keep it in position during the subsequent processes. Next, take a clean cover glass and put a small drop of a very thin mounting medium in the middle of it. Invert it, and carefully place it on top of the convex surface of the mounting medium in the cell, parallel to the ring (fig. 1, B, m.). The drop which has been placed on it will facilitate the spreading of the mounting medium of the cell from the centre of the cover glass towards its periphery.

In a newly mounted cell the cover glass should not rest on the ring. It must be separated from the latter by a layer of mounting medium, about 1 mm. thick (fig. 1, C, m.). If an overflow of the medium occurs, it should be immediately stopped by wiping the ring with a folded piece of blotting paper, pressing it firmly against the side of the ring. But this rarely happens when the ring is a little broader than the cover glass.

The layer of the mounting medium between the cover glass and the ring serves two purposes. It allows any air bubbles to escape, and it makes provision for the gradual reduction in volume of the mounting medium due to the evaporation of the solvent.

Specimens mounted by this method seventeen years ago are still in perfect condition, and the balsam shows no signs of cracking, or bubble formation, as often happens when glass or metal rings are used, and when no provision is



made for the reduction in volume, by putting a sufficient quantity of mounting medium to form a layer between the cover glass and the ring.

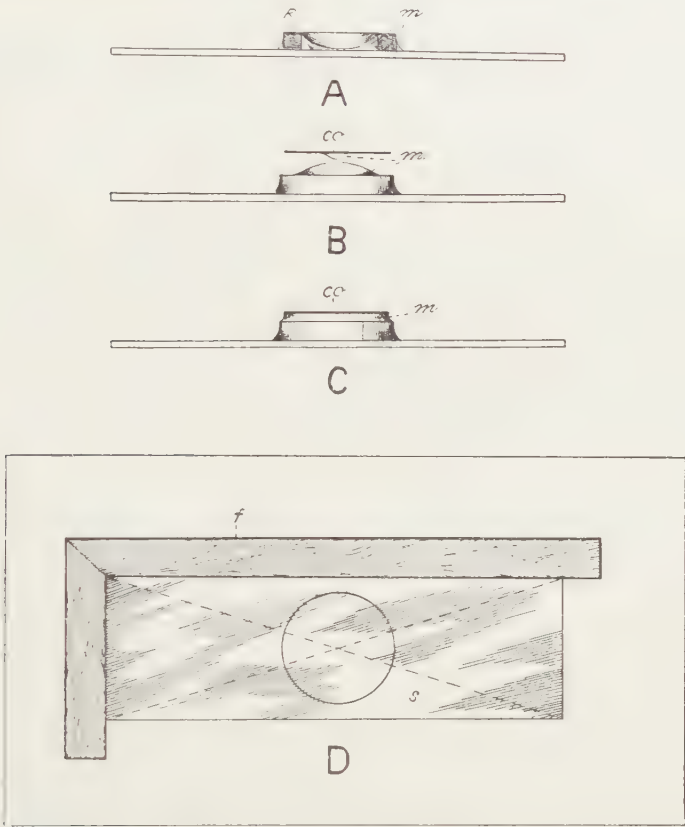


FIG. 1.—A, Section of cell, showing concavity formed by mounting medium (m.) in ring (R.); B, cell filled with mounting medium (m.), and ready to be covered with cover glass (co.); C, mounted cell, cover glass (co.) separated by layer of mounting medium (m.) from ring; D, adaptation for arrangement of rings in middle of slides (see text).

The appearance of the preparation is greatly improved when the cell is ringed with asphalt varnish on the turn-table. But this is better done much later, when the mounting medium has set hard.

## A CASE OF INTER-GENERIC MATING IN THE ICHNEUMONIDAE

By W. H. THORPE, M.A., Ph.D., F.R.E.S.

(Department of Entomology, Zoological Laboratory, Cambridge.)

DURING the course of the last four years many thousands of the Ophionine Ichneumonid *Nemeritis canescens* (Grav.), an endoparasite of *Ephestia* spp. have been reared in this laboratory. As is usual throughout the cosmopolitan range of this species, only females were produced, reproduction being entirely parthenogenetic. In fact the only males on record are three individuals obtained in Berlin by Dautert-Willimizik (1931) and nine by Hase (1937). Although the normal host is *Ephestia* spp. it has been found possible to rear it on other hosts such as *Meliphora grisella* (Fab.) and *Galleria mellonella* (L.), and in some areas these insects are probably parasitised naturally (Thorpe and Jones, 1937).

In June 1937 my assistant Mr. F. Bloy obtained two male Ophionines from a newly obtained stock of *G. mellonella* which had been artificially infected with *N. canescens* and from which the female parasites were already emerging. No detailed description of the male of *N. canescens* being available, the insects, after being fed on honey and raisins, were placed in a jar containing a dozen freshly emerged females on the assumption that they might be the males of the species. One of them soon commenced pursuing the females and effected copulation, which lasted for about half an hour. Copulation was again observed later in the same day and the males and females were kept together for three days. They were then separated, the females being given larvae of *Ephestia kühniella* Zell. for oviposition and the males being provided with food and water until their death on June 19th—ten days later. On close examination it became clear that the males were not those of *Nemeritis* at all but of a species of *Angitia*, subsequently identified by Mr. Kerrich and Mr. Perkins as *A. chrysosticta* (Gmel.). Shortly afterwards females of this species also emerged from the same *Galleria* stock and since then a quantity of both sexes has been obtained. After copulation the female *Nemeritis* freely laid eggs which gave rise to female *N. canescens* normal in every respect. It seems that instances of inter-generic mating are sufficiently rare to be worth putting on record. It is also worthy of note that *G. mellonella* has not hitherto been recorded as a host for *A. chrysosticta*.

The function of the exceedingly rare male of *N. canescens* is still a mystery. Those recorded by Dautert-Willimizik appear to have shown no interest whatever in the females and to have died after twelve days without effecting copulation. On the other hand, the nine individuals reared by Hase were sexually vigorous and copulated freely. Nevertheless the females thus presumably impregnated produced normal female progeny only. Hase inclines to the view that there are two distinct types of males, one fertile, the other sterile and functionless, but the evidence at present is much too slender to enable any conclusion to be arrived at. It may be, of course, that further investigations will reveal the existence of functional males with normal sexual reproduction restricted to certain geographical areas. On the other hand, the males may never be more

than sporadic and functionless. Since it parasitises an insect of world-wide economic importance, *N. canescens* has been the subject of studies in many different parts of its range. It is therefore all the more remarkable that bi-sexual reproduction, if it is anywhere the normal process, has not so far been described. The fact, recorded by Wojnowskaja-Krieger, that the female lacks a spermatheca, while lending weight to the view that parthenogenesis is the sole method of reproduction, does not of course prove that fertilisation is impossible.

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#### BOOK NOTICE.

*Land of the Red Bird*. By L. E. CHEESMAN. London (H. Joseph, Ltd.). Pp. 300, 16 pls. 12s. 6d.

This work is the popular account of Miss Cheesman's expedition to the Cyclops Mountains and Lake Sentari in New Guinea to collect insects on behalf of the British Museum.

As its title suggests, the book is concerned more with the account of the expedition and the many unusual incidents which happen on visits to such out-of-the-way parts than with entomology, although the authoress uses the geographical distribution of insects to suggest the origin of the New Guinea fauna. A map is supplied by the publishers, pasted inside the covers. A protest may be registered against this practice on behalf of those who keep books of permanent value.



## A NOTE ON THE FALLACIOUSNESS OF THE THEORY OF PRETRACHEATION IN THE VENATION OF ODONATA

By LT.-COL. F. C. FRASER, I.M.S. Retd., F.R.E.S.

IN recent years considerable doubt has been thrown on the Comstock-Needham theory of pretracheation which pronounces that the main nervures of insects are laid down along the courses pursued by the tracheae in the larval wing, and that the tracheation reflects the primitive state of venation of the imago. Against such a theory, a lack of conformity of the venation with the tracheation has been demonstrated in the Trichoptera, Diptera, Hymenoptera and Odonata. In the case of the last, Tillyard, Martynov and Carpenter have all thrown doubt on pretracheation, the first named showing, I think conclusively, that Needham's assertion that the Radial sector crosses over two branches of the Media is entirely fallacious.

It was the homologising of the venation of the Odonata with that of other orders of insects by Lameere and Tillyard that first threw doubt on this particular example of pretracheal deception, but later both Tillyard and Carpenter brought in the evidence of palaeontology finally to disprove it.

In addition to correcting the views on the formation of the Radial sector and Media, Tillyard produced evidence to show that the Cubitus does not divide into  $Cu_1$  and  $Cu_{1+2}$  as Needham had stated, and as appears to be the case from the evidence afforded by larval tracheation, but that the supposed bifurcation is actually a meeting of  $Cu_{1+2}$  and IA, the nervure  $Cu_1$  being obsolete in the Odonata. He showed that the anal nervure, IA, left the common stem, which it shared with  $Cu_{1+2}$ , and passed by way of Ac (Anal-crossing of Tillyard or  $Cu_1$  of Ris) to the Anal bridge (Ab), to again converge on and meet  $Cu_{1+2}$ . At the point where Ac met Ab, the anal nervure threw off a secondary branch (recurrent branch of Calvert),  $A'$ , which ran for but a short distance to join the posterior border of the wing. Thus the path of the anal nervure as laid down by Tillyard and as generally accepted now is as follows: Stem of Cubitus + Ac + Ab + Distal portion of IA.

Martynov (1929) also expressed his distrust of larval tracheation as a guide to the imaginal venation. He wrote: "Coincidence of the tracheation with the neurulation is only partial in Odonata and still less so in the Agnatha. These and many other facts favour the opinion that the correspondence of the tracheation to the neurulation was elaborated secondarily; consequently the interpretation of the wing neurulation can be based on the tracheation only with very great caution."

More recently, Carpenter (1931) has expressed doubt on Tillyard's interpretation of the path taken by the anal nervure. Of it he says: "I do not believe that either tracheation or the data of palaeontology have proved that Ac is a portion of the true anal vein, IA... on the contrary, I consider the tracheal studies to be as negative as those on the Radial sector and Media, and regard the palaeontological evidence as positive evidence against the accepted understanding of Ac." The evidence referred to here by Carpenter is the apparent inconstancy of the presence of the nervure Ac in the Pro-tanisopterous wings. From this occasional absence of the nervure Ac, he very justly argues that, if a hiatus is found to exist in the supposed path of the

anal nervure, then this path cannot be the actual one taken by the nervure. In place of Tillyard's roundabout path, he considers that IA has an independent origin from the base of the wing in the Anisoptera, but, at the same time, continues to accept the theory as applied to the Zygoptera, for he says: "There is no doubt of course that these veins (CuP and IA) are fused in *Kennedya* and *Progonura*," that is, in the Protozygoptera and, by inference, in the Zygoptera.

Tillyard (MS.) later accepted Carpenter's views as applied to the Anisoptera, but still clung to his belief that the anal nervure arose by a common stem with CuP in the petiolated Zygoptera (Coenagrionidae). Neither he nor Carpenter appears to have considered the possibility or probability of this nervure arising independently in the latter insects.

In a communication received in 1936, the late Dr. Tillyard invited my attention to an interesting condition of the anal nervure in the archaic species *Hemiphysalis mirabilis* Selys. He pointed out that in the wings of this dragonfly the proximal continuation of the anal bridge, which he had designated as the nervure A', was continued along the posterior border of the wing to as far as its base. Although it was fused with the border, it had preserved its individuality and could be distinguished as a distinct nervure running parallel with and closely apposed to the border of the wing (fig. 1, b). He likened its appearance to a similar fusion of the bases of the Radius and Media; an appearance which has been aptly compared with the two barrels of a sporting-gun.

From Dr. Tillyard's letter, it was not quite clear as to whether he considered this extension as an independent origin of the anal nervure from the base of the wing, or merely an extension of his so-called "secondary anal vein" ("recurrent anal vein" of Calvert), but as he had stressed the fact that he could discern no trachea descending Ac, it is to be presumed that he considered the former explanation to be the correct one.

Fortunately along with the communication came an ample supply of material, so that I was able to satisfy myself that the condition he had described was correct. It is to this communication and material that the present research owes its inspiration.

In some of the wings examined, moulds had obscured the details of the basal venation, but in some forty others these were made out quite clearly. The majority exhibited the condition of the anal nervure just as Tillyard had described it, but in some the nervure A' was separated from the posterior border of the wing for a considerable distance, and in two this separation was carried right up to the base of the wing, as in the AGRIONIDAE and Anisoptera (fig. 1, a). In the majority, a short cross-vein, situated either a little distal or a little proximal to the level of Ac, connected A' with the posterior border. It seemed clear that, in *Hemiphysalis*, if the evidence of larval pretracheation could be ignored, the anal nervure had an independent origin from the base of the wing.

Dr. Tillyard claimed that this condition of A' was unique among the Coenagrionidae, and therefore suggested removing *Hemiphysalis* from this superfamily and placing it in one of its own which he proposed to name the Hemiphysalioidea.

Before accepting such a claim or acquiescing in such a drastic proposal, I thought that it might be advantageous to carry out an examination of a number of genera belonging to the Coenagrionidae, to see if any evidence of a similar condition of the anal nervure could be found, especially as it was one which

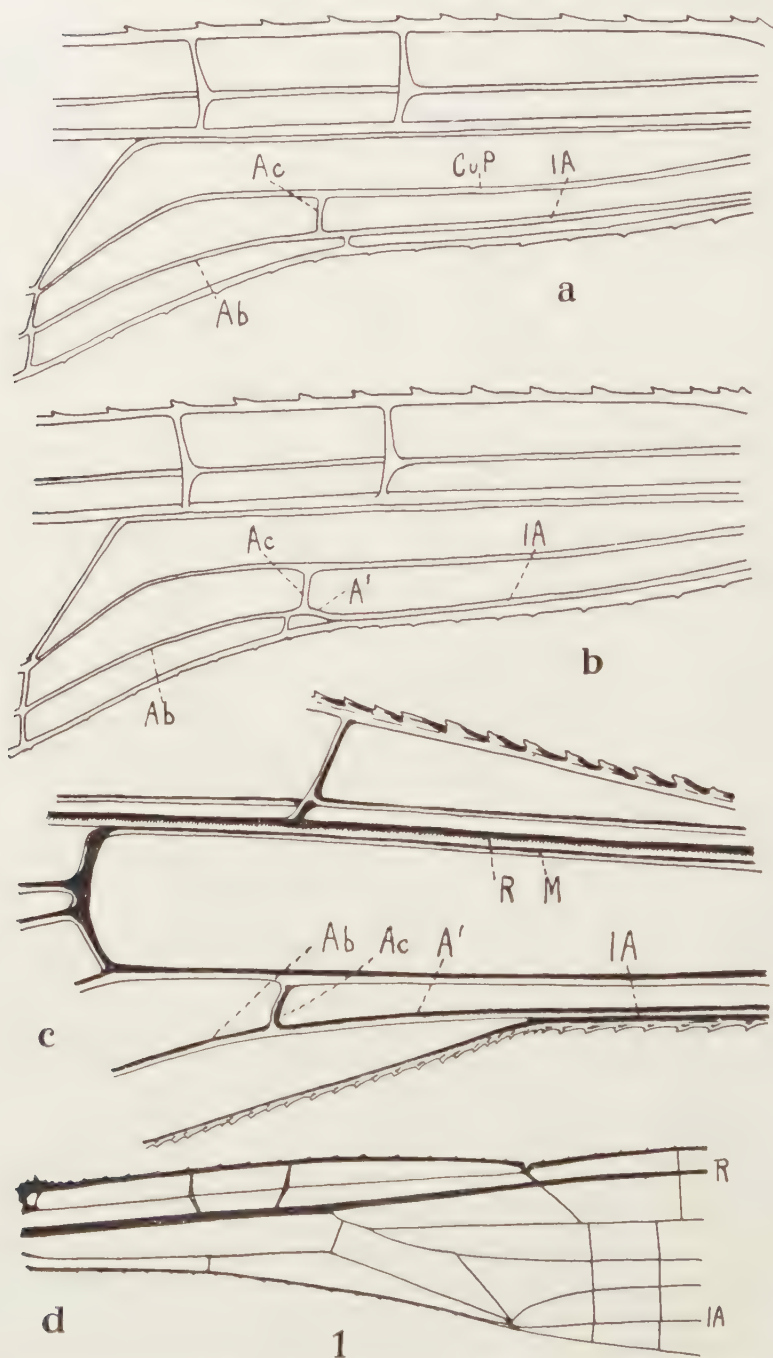
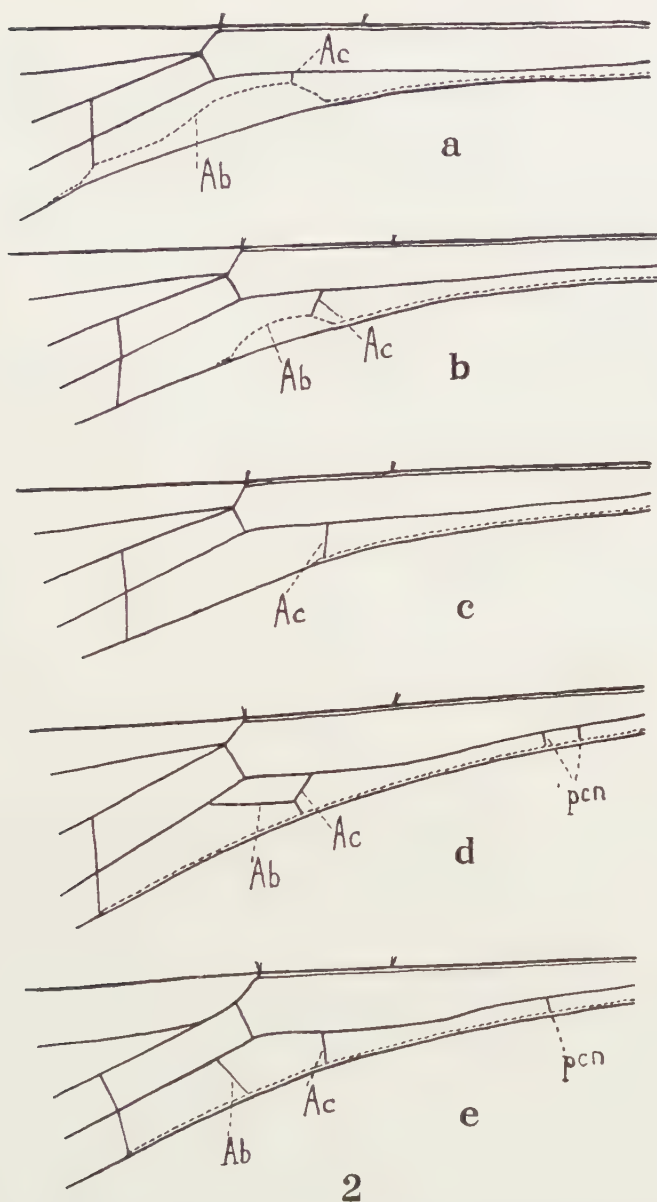


FIG. 1.—Basal portion of wing of: *a*, *Hemiphysalis mirabilis* Selys; the anal nerve is entirely separated from the border of wing. *b*, The same, but the anal nerve is here fused with the wing border. *c*, *Mesocnemis singularis* Karsch, the anal nerve is partly separated and partly fused with the border; note the great thickening of the Radius and how reduction of the wing has brought the discoidal cell on to the border, only the anal nerve intervening. *A'*, Secondary or recurrent anal nerve of Tillyard, *Ab*, Anal-bridge, *Ac*, Anal-crossing, *CuP*, Posterior Cubitus or *Cu<sub>1</sub>*, *IA*, anal nerve, *R*, Radius, *M*, Media.





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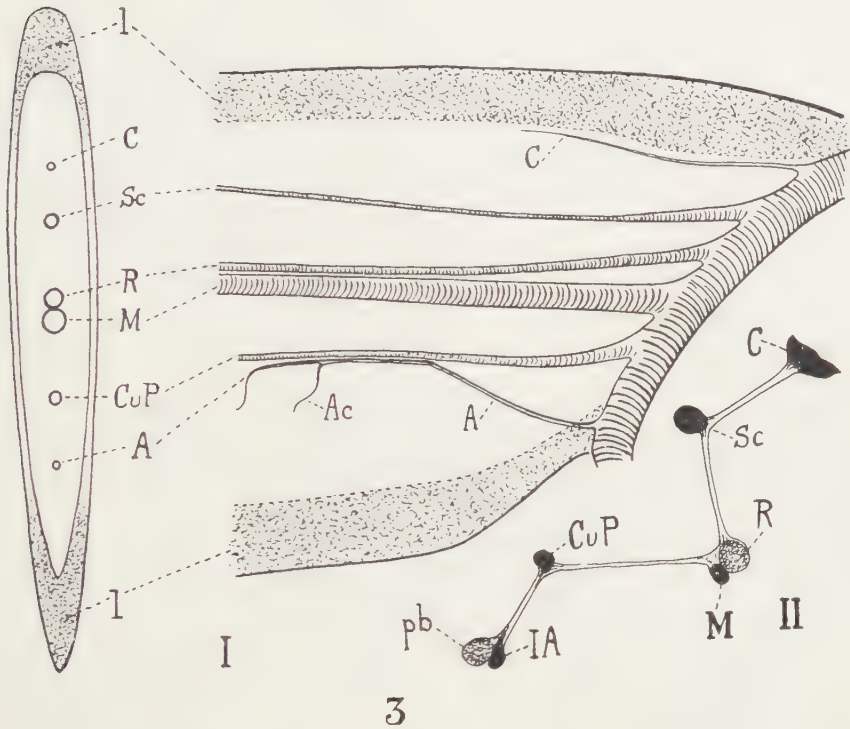
FIG. 2.—Posterior portion of base of wing of: *a*, *Esme*, *b*, *Disparoneura*, *c*, *Melanoneura*, *d*, *Platysticta*, *e*, *Drepanosticta*. The anal nerve, IA, is shown by dotted lines in all figures. Note the gradual reduction of the anal nerve in figures *a*, *b* and *c*. (*pcn*, postcostal or postcubital nerves.)

might have been very easily overlooked. Unfortunately, at the time I confined my examinations to genera belonging exclusively to the family COENAGRIDAE—*Pseudagrion*, *Ceriagrion*, *Ischnura*, *Enallagma* and others being employed for this purpose. I found in them only an abrupt thickening of the posterior border of the wing, beginning from the point at which it was joined by the nervure A', and such as might be caused if that border had suddenly been reinforced by its junction with another nervure. Although such a condition might be accepted as partial proof or evidence of the anal nervure pursuing a course along the border of the wing, I was not at all satisfied, and thinking that the condition found in the COENAGRIDAE reflected that of the entire superfamily I abandoned the search for the time being.

A few months ago, whilst examining some specimens of *Esme*, it occurred to me that this group exhibited in itself a complete series demonstrating the reduction of the anal nervure, so that species belonging to it might be expected to show better evidence of the condition found in *Hemiphysbia* than I had found in the COENAGRIDAE. A brief examination under the microscope convinced me that my deduction was correct: all the specimens before me showed the "double-barrelled" appearance of the posterior margin as clearly as in *Hemiphysbia*. All the genera belonging to this group were then examined, and all examinations proved to be positive, even in the case of *Melanoneura*, where the anal nervure is apparently absent (fig. 2, *a*, *b* and *c*). In this latter genus the nervure could be seen clearly, running from the base of the wing and ending imperceptibly a fraction distal to the point where Ac joins the posterior border of the wing. In some specimens of *Esme* and *Phylloneura*, the distal end of the anal nervure could be seen prolonged for a short distance along the wing margin, distal to the point where it apparently ends on that margin, so that it appears clear that the anal nervure was at one time considerably longer than suspected in these genera (fig. 2, *a*).

Following on the examination of the group *Esme*, a great number of other genera belonging to the families PROTONEURIDAE, PLATYCNEMIDAE, PLATYSTICTIDAE and LESTIDAE were examined, all with positive results (fig. 1, *c*). The individuality of the anal nervure is not well shown in the latter family, but *Megalestes major* Selys, of the SYNLESTINAE, exhibits the double-barrelled condition of the posterior border to an even better degree than if found in *Hemiphysbia*, probably because of its larger size and coarser build (fig. 3, II). In the PLATYSTICTIDAE a very interesting variation in the course of the nervure is found. Species belonging to this family appear to have lost the anal nervure, as in genus *Melanoneura*, but actually it is hidden in the posterior border. Instead of stopping short at the level of Ac as in *Melanoneura*, it is prolonged along the border to as far as the level of the cross-nervure descending from the distal end of the discoidal cell. Even in *Drepanosticta*, where a portion of the anal bridge, Ab, is still preserved, the anal nervure does not follow along it as Tillyard supposed, but chooses the posterior border of the wing instead. It will be seen that, in *Platysticta deccanensis* Laidlaw, the nervure Ab ends on the underside of the discoidal cell, so that if the anal nervure followed it, it would end in the interior of the wing instead of on the border, which is its normal destination (fig. 2, *d* and *e*).

With regard to the postcubital nervure found in this family, Tillyard postulated that it represents the supporting nervure at the end of the obsolete CuA. I very much doubt if this is the correct explanation and believe that it represents an additional cubital nervure preserved by twigs from the anal trachea, and analogous to those nervures found in the ancient MEGANEURIDAE



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FIG. 3.—I. Base and transverse section of the base of a larval wing-case to show the distribution and relative sizes of the tracheae. II. Transverse section in paraffin of base of imaginal wing of *Megalestes major* Selys, to show two sets of duplicated nervures, one the fused Radius and Media, the other the fused anal nervure and border of wing. A, anal trachea, Ac, trachea of anal-crossing, C, costa, CuP, posterior cubitus, IA, anal nervure, l, lacuna, M, media, pb, posterior border of wing, R, radius, Sc, subcosta.

or recent larger forms of Zygoptera. That this is the case appears to be proved by the fact that this nervure is quite commonly duplicated in the PLATYSTICTIDAE, especially in *P. deccanensis* Laidlaw. It would hardly be so, if it represented the end of CuA (fig. 2, d, *pcn*).

The weight of the evidence described above sufficed to show that the genus *Hemiphlebia* did not differ materially from the rest of the Coenagrionidae; the only difference was one of degree. There was, however, no evidence to show whether the nervure, which was fused with the posterior border of the wing, was the anal nervure itself or merely a recurrent branch of that nervure. In an effort to find a solution to this problem a close study of the larval wing was made, particular attention being paid to a comparison of its tracheation with the imaginal venation. The result of this investigation follows.

In the larval wing it may be seen that the anal trachea joins the cubital trachea to form a common stem, and leaves it again by the medium of Ac so clearly, that it seems superfluous to look for any independent or other origin of the anal nervure from the base of the wing. Nevertheless, if the basal area of the larval wing be examined carefully, first on the flat and then in section,



several significant facts bearing on the origin of this nervure will at once appear; I will deal with these in order of importance:

1. The calibre of the tracheae is seen to enlarge from the periphery towards the central parts of the wing, that of the Media being by far the greatest diameter and at least one-third that of the Radius or more than double that of any of the others. Conversely, the peripheral tracheae are thin and short, the Costal being nearly obsolete and the Analis approaching that condition, especially in the Zygoptera.

2. The tracheae are seen to crowd into the central parts of the wing. Even the Analis, which arises at or outside the periphery, runs inwards obliquely to assume a position nearer the centre of the wing (fig. 3, I, 4).

It is clear from these two facts that the central parts of the wing secure a much richer tracheal supply than do the peripheral: the latter, by comparison, appearing to be starved.

3. The larval wings only partially fill the wing-cases, broad spaces filled with fluid, occupying the costal and posterior borders of the cases. In section, these spaces are seen to be triangular lacunae and it is evident that their function is to supply food and oxygen to the peripheral parts of the wings. Thus the starvation of these parts is merely apparent, since they are independent of the tracheal supply. The basal portion of the anal nervure, being a peripheral structure in the Coenagriodea, falls into this category, and thus the reason for the anal trachea abandoning it appears to be quite clear.

4. The anal trachea is seen to take its origin from the main tracheal arch at quite a long distance from the origin of the Cubitus. It is logical to argue that if its function were merely to reinforce the Cubitus, it would have had its origin in juxtaposition to it, or, what is more probable, the Cubitus itself would have increased in size to secure this end. I do not believe that this was its original function: on the contrary, arguing from its more peripheral site of origin, I think that it must have originally served the anal nervure, and that, when this nervure, through reduction of the base of the wing, became approximated to the periphery of the wing, it became independent of the tracheal supply, which it now found in the lacunal fluid along the posterior border of the wing-case. Under such conditions, the anal trachea might either atrophy or turn inwards to assist in supplying the medial parts of the wing, and it is this latter course which has been adopted. So long as the anal nervure pursued a course along the periphery of the wing, it was independent of the anal trachea, but from the moment it left the periphery by  $A'$ , it again became dependent on some tracheal supply. It is just at this level, viz. the level of the anal crossing, that the anal trachea leaves the Cubitus and turns back to rejoin the anal nervure. One may see here, also, why the cubital nervure  $Ac$  has persisted as a constant vestigial structure throughout recent Odonata: it is because it offered the most direct path for the anal trachea to return to the anal nervure, and since it has continued to function as that path to the present day it has been preserved in preference to those other cubital nervures which were situated either more proximal or more distal to it. *The phylogenetic importance of this short cross-nervure  $Ac$  cannot be exaggerated.* Its presence in modern Odonata shows not only the path the anal trachea has taken, but also shows that the base of the wings has at one time gone through a process of great reduction, this process having been responsible for driving the trachea inwards.

5. In the larval wing, the tracheae of the Radius and Media are well separated at the base, from which point they converge and gradually meet. In the imaginal wing these two nervures are seen to be in the closest apposition

right from the base of the wing. If they had been governed by pretracheation they would be separated at the base.

6. The trachea of the Media is much larger and more robust than that of the Radius. In the wings of the imago it will be seen that this has been reversed and that the Radius is now more than double the thickness of the Media! If pretracheation governed venation, surely the relative sizes of the trachea and nervures would be similar? It is impossible to reconcile such a discrepancy with the theory of pretracheation. It is because of this reversal in the respective sizes of the Radius and Media that one finds a many-branched Media in the larval wing, whereas a many-branched Radius is found in the imaginal wing. A fine example of the thickening of the Radius at the expense of the Media is found in the genus *Perilestes*, where the Radius runs like a thick rod through the length of the wing, quite dwarfing all other longitudinal nervures (fig. 1, *d*).

In the same genus is to be found ample evidence to prove that reduction of the base of the wing has gone on and is still going on in the Coenagriidae.

I have already shown that in group *Esme* the anal nervure in genus *Melano-neura* is a mere remnant fused with the border of the wing from the base to the level of Ac (fig. 2, *c*), and that in genus *Disparoneura* this remnant is extended distally by a vestige of Ab (fig. 2, *b*), and that in the genera *Esme* and *Phyllo-neura* the nervure is still further extended by a complete Ab, which may run on for one or two cells into the wing (fig. 2, *a*). Again in the PLATYSTICTIDAE I have shown that the anal nervure is fused with the border of the wing from its base to the level of the distal end of the discoidal cell (fig. 2, *d*, *e*).

In none of these genera is the anal nervure visible to the naked eye and in none does it reappear again in the body of the wing. In *Perilestes*, however, one sees this extraordinary phenomenon, and that, although the base or origin of the nervure is absent, its body is present in the outer wing. The very ambiguity of this ought to have led to the truth; actually, under the microscope, the basal portion of the nervure is seen to be fused with the border of the wing, as in the PLATYSTICTIDAE, and only at the distal end of the discoidal cell does it appear for the first time as a macroscopical object! From this point it runs for some distance parallel to and well inside the wing border. Previous authors have stated that the discoidal cell is in actual contact with the wing border; one has stated that its nose is buried in that border, and Munz shows it so. Actually the anal nervure intervenes between it and the wing border, nipped, as it were, between the opposing structures. Clearly only reduction of the base of the wing could bring about such an extraordinary condition, since the nervure Ac is present and fixed, although there is no longer any need for such a nervure at this point in *Perilestes*, nor at any point in those genera in which the anal nervure has become obsolete.

It is convenient as well as instructive, at this point, to turn to the imaginal wing, since in its venation is to be found further evidence of the invalidity of the theory of pretracheation.

It will be seen that the Costa is by far the thickest and most heavily built part of the wing and yet it is supplied only by a thin, vestigial trachea! Only a trachea of the size of that of the Media would meet its requirements; it is clear, therefore, that it must draw its sustenance from the Costal lacuna in the wing-case, an explanation which parallels that of the anal nervure.

Secondly, if the anal nervure arises, as is claimed, by a common stem with the Cubitus, then there ought to be some evidence of this in the imaginal wing, simulating the double-barrelled appearance so characteristic of the fused Radius

and Media. After examining a great number of species belonging to many genera and families, I have been quite unable to find in the Cubitus the slightest suspicion of any such appearance. This too must therefore be accepted as evidence pointing to a basal independent origin of the anal nervure.

Lastly, if the wing of a Coenagrionid be embedded in paraffin and sections cut through its base, proximal to the level of Ac, the following points will be noticed (fig. 3, II) :

Owing to the deep concavity and steep convexity of the alternating nervures, the section is seen to be **W**-shaped; the membrane stretching tautly between the nervures, attached to the inner sides of the bordering nervures, and to the under- and upper-sides of the convex and concave nervures respectively. The Radius and Media, lying in the closest contact, are seen perched upon the apex of the middle stem of the **W**, the Radius being three times the diameter of the Media, and in strong contrast to the relative sizes of the tracheae supplying the two same nervures. CuP is slightly larger than the Media, and shows not the slightest suspicion of any duplication such as I should expect if it was composed of the Cubitus and Anals. On the other hand, the posterior border of the wing is clearly seen to be made up of two nervures and shows a striking similarity to the section of the fused Radius and Media. The anal nervure is the smallest structure entering into its construction and is easily determined by the superior position it occupies as a convex nervure. In the section of *Megalestes major* Selys, shown in fig. 3, the Radius and posterior border of the wing were pale brown in contrast to the deep black of the other nervures.

I have produced sufficient evidence to throw discredit on the theory of pretracheation of the imaginal venation of the Odonata, and, in the course of this, have shown that the anal nervure, throughout the Coenagrionidea, arises independently of the Cubitus. I have also shown that, through reduction of the base of the wing, the anal nervure has been brought on to the border of the wing and rendered independent of its trachea, which, thus freed, has transferred its association to the Cubitus. Because of the utilising of the cubital nervure Ac, by the anal trachea, when finally leaving the Cubitus, this cross nervure has become "fixed" or preserved and is so constant in its appearance that it has become an ordinal character of recent Odonata.

Carpenter points out that in the Protanisoptera there are several cubital nervures, none of which is more oblique or more robust than the others. He therefore considers that there is no nervure Ac in the Protanisoptera and that they differ from the Protozgyoptera by having an independent origin of the anal nervure from the base of the wing. It is mainly on this character that he argues a dual origin for the Odonata, from Zygopterous and Anisopterous ancestors.

I am not prepared to give an opinion about the presence or absence of Ac in the Protanisoptera, since obliquity is not a necessary character for this nervure and as regards its relative size, this would be extremely difficult to judge in a fossil wing. However, apart from this, Carpenter has overlooked an insuperable difficulty. The nervure Ac may be absent in the Protanisoptera but *it is undoubtedly present in the Anisoptera*. Hence, for the reasons which I have already given, Carpenter's Protanisoptera, to be the ancestors of the Anisoptera, must first of all have passed through a stage of reduction, that is, the Protozgyoptera must have intervened between them and the Anisoptera. This, of course, is possible, since they may represent that stage where reduction has begun to bring the anal nervure towards the periphery of the wing, and



to force the anal trachea to transfer itself to the Cubitus, after which, the anal-crossing is developed as a natural sequence. There are, however, strong arguments to bring against such a possibility, but as these fall rather outside the scope of the present paper I must leave them to be answered on another occasion.

#### SUMMARY.

In this paper, the theory that pretracheation reflects the vestigial neurulation of the imaginal wing in the Odonata, is shown by the following arguments to be invalid :

1. The tracheation by its distribution and capacity is shown to be primarily and mainly concerned with the nourishment of the wings.

2. The anal nervure at its origin, in the Zygoptera, is shown to run a course along the posterior border of the wing and not to arise by a common stem with the Cubitus.

3. The anal trachea is found to arise at the level of the anal nervure, and, at its origin, to be far removed from the Cubitus, to which it runs as if to reinforce it. If the latter was its function, then it should arise in juxta-position to the Cubitus. From the position of its origin, it probably and primarily supplied the anal nervure, and its association with the Cubitus represents a secondary formation.

4. The Cubitus, CuP, is not found to exhibit the "double-barrelled" appearance which one might expect to see if it was composed of two nervures at its base.

5. The tracheae of the Media and Radius are separated at the base in the larval wing, whereas they lie in the closest apposition from their origins at the base of the wing, in the imago.

6. The comparative sizes of the Radius and Media are reversed in the larva and imago. It is this fact which has led to the error in the interpretation of the branches of the Radius and Media.

It is suggested that the change in the course of the anal trachea arose from a reduction of the base of the wing which rendered the anal nervure independent of a tracheal supply. Since the same tortuous course of the trachea is pursued in the Anisoptera and Zygoptera, both sub-orders must have undergone this reduction, and the Anisoptera must have arisen from a Zygopterous form by a secondary or recurrent broadening of the wings.

Pretracheation may affect the neurulation of the imaginal wing by "fixing" certain vestigial structures such as Ac and the oblique nervure running between Riii and IRiii. Beyond this, interpretations of the neurulation which are based on it are of very doubtful value.

Professor Needham says (1935) : "An effort has been made to cast doubt upon the validity of all evidence from tracheae because of the fact that they are of no use in determining homologies in the Trichoptera. It is as if a mammalogist were to say that because whales have no teeth phylogenetic evidence from mammalian dentition may be disregarded." To this I would reply that : "Although all Trichoptera, so far examined, have shown a lack of correspondence between the tracheae and nervures, all whales are not edentulous. Whilst some species are so, others are born with embryonic teeth which disappear early, and others still have a fine complement of teeth. If such a complete chain of evidence could be produced for the theory of pretracheation, our belief in it might be restored."

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# THE FRIGHTENING ATTITUDE OF A DESERT MANTID, *EREMIA-PHILA BRAUERI* KR. (ORTHOPTERA, MANTODEA)

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Communicated by Dr. W. H. THORPE, F.R.E.S.

THE peculiar frightening attitude of a desert mantid, *Eremiaphila braueri* Kr., described below was first observed by me on March 23, 1936, about two miles from Pasni (Baluchistan).

The mantid, a mature female, was found walking on a stretch of hard, "kallar" (saltish) soil. When chased, it ran fast for about four minutes, then suddenly turned round, unfolded its wings and stood up on its hind-legs like a performing bear (fig. 1). When an object—finger or stick—was presented, the insect fiercely pecked at it with its mandibles, while catching it with the fore-legs. The middle legs remained idle. On my moving around the insect in a circle, the latter also turned round and always kept facing me. This went on for over twenty minutes, and all the while the insect was standing on its hind-legs. At 20 feet the insect stopped turning round with me, but when I moved 5 feet closer, the performance was started again. Presumably, the insect cannot see distinctly beyond about 15 feet. When I stamped my foot close (6 inches) to the standing mantid, it reeled back, but soon regained its poise. After this I stood absolutely still for a few minutes. The mantid then assumed its normal position on the ground and crawled away.

These observations were confirmed several times in March and early April, 1936, and again in March, 1937.

The mantids met with were always mature or semi-mature females, and eggs are probably laid, under Pasni conditions, in March and April, *i.e.*, soon after the rain, which falls, as a rule, in winter. An examination of the stomach contents showed that the principal food of the mantid consists of ants. It is also interesting to note that the mantid was always found on hard, clayey and "kallar" soils, and never on the neighbouring sandy areas which are locally known as "reks."

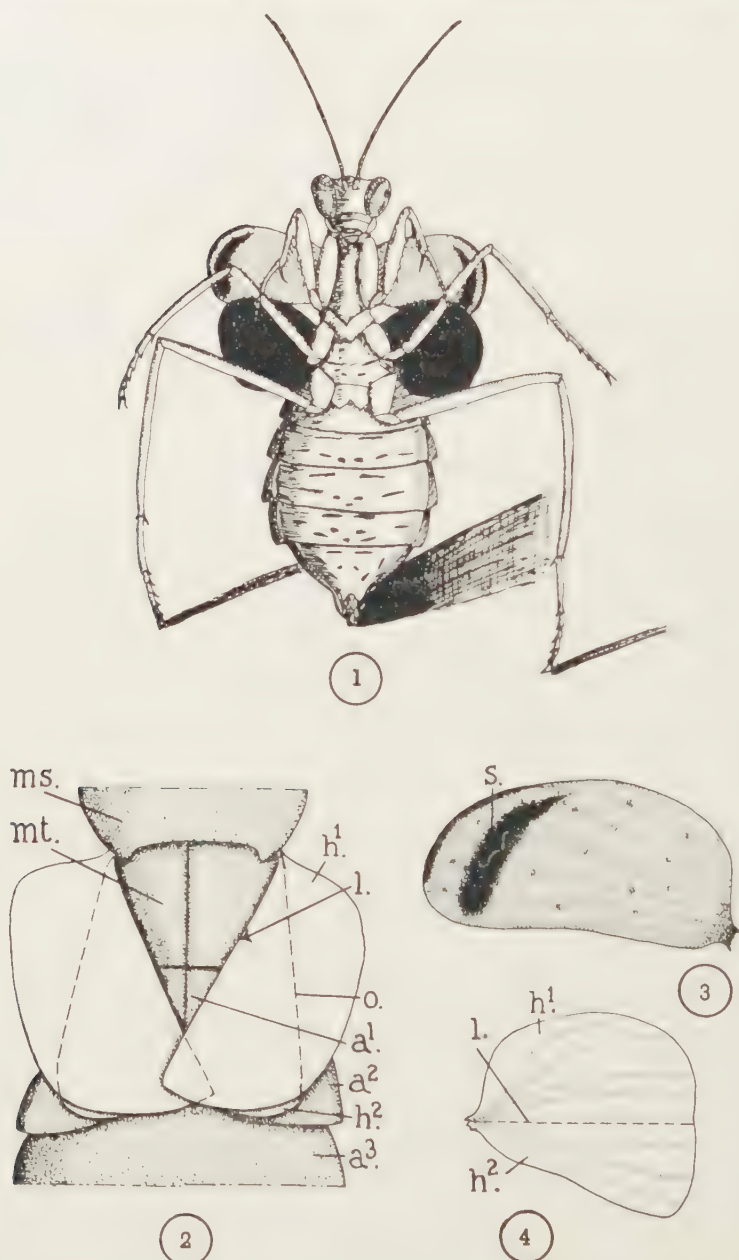
The purpose of the peculiar attitude described above appears to be to frighten away, by suddenly turning at bay, its natural enemies, such as lizards and possibly birds. The general dorsal body-colour of the mantid is a light greyish-brown, and harmonises with the colour of the ground on which the insect is generally found. The venter is similarly, but more lightly, coloured. The wings are short and non-functional for flight. They play an important rôle in the frightening attitude, however, and are conspicuously coloured as described below :—

*Fore-wing.—Dorsal side.* Greyish-brown, like the rest of the body dorsum. *Ventral side* (fig. 3). Faint violet, with the exception of (i) a narrow streak at the outer edge, which is brownish and (ii) a prominent, dark-coloured streak (*s.*) in the outer third of the elytron.

*Hind-wing.—Folds along a line (l.)* about two-thirds distance from the anterior margin of the wing (figs. 2 and 4). *Dorsal side.* Purple—lighter towards the wing-base, and almost black elsewhere. *Ventral side.* The same as on the dorsal side, except that the light-coloured basal area is somewhat larger.

PROC. R. ENT. SOC. LOND. (A) 13. PTS. 4-6. (JUNE 1938.)





FIGS. 1-4.—1. A mature female of *Eremiaphila braueri* Kr. in the erect, or frightening, attitude, with wings expanded. Front (ventral) view, facing the enemy.  $\times$  c.  $1\frac{1}{2}$ . 2. Dorsal view of a portion of the thorax and abdomen, showing the hind-wings folded, in the resting position, over the body. (The fore-wings are not shown in the figure.)  $\times$  c. 4. 3. Ventral view of the right fore-wing.  $\times$  c. 3. 4. The right hind-wing in the expanded position, showing the line along which folding occurs. The principal veins are shown in dotted lines.  $\times$  c. 3.

$a^1$ ,  $a^2$ ,  $a^3$ , first, second and third abdominal terga respectively;  $h^1$ ,  $h^2$ , upper and lower folds respectively of the right hind-wing;  $l$ , line along which the hind-wing folds;  $ms.$ , mesothorax;  $mt.$ , metathorax;  $o.$ , outer margin of the lower fold of hind-wing;  $s.$ , prominent dark streak on ventral side of fore-wing.

THE EFFECT OF THE HUMIDITY OF THE ENVIRONMENT ON SEX  
RATIOS FROM OVER-AGED OVA OF *PSEUDOCOCCUS CITRI*  
RISSO (HEMIPT. COCCIDAE)

By H. C. JAMES, B.Sc., Ph.D., F.R.E.S.

(Entomological Department, Cambridge.)

In a previous paper (1) it was shown that the mean of a series of family sex ratios of *Pseudococcus citri* from over-aged ova showed a higher proportion of males than the mean of a series of family ratios from females fertilised at the normal time. This result had been obtained from females which were maintained in saturated air during the period of the maturation and ageing of the ova, and it was decided to ascertain whether females kept in dry air during a corresponding period would exhibit significant alterations in their sex ratios.

In order to obtain an environment in which the required low humidity could be maintained in spite of the moisture continuously given off by the insects and their host plants, an apparatus was constructed which consisted essentially of four large glass jars (fig. 1 G.G.) fitted with wax-impregnated cork bungs (fig. 2 C.B.) and held immersed to the neck in a water-bath by means of lead weights (fig. 1 B.W. and L.W.). Each bung was pierced by two glass tubes, and all were connected by rubber tubing as shown in figs. 1 and 2, so that a continuous current of air which had been dried by passage through calcium chloride could be drawn through by means of a filter pump. Each of the jars (G.G.) contained a small bottle (fig. 1 B.C.) half-filled with Sach's plant nutrient solution in which was growing a cutting of *Coleus* (Labiatae). The latter was held in position by a plug of cotton wool (fig. 1 C.P.) in the neck of the bottles, and these proved most efficient in preventing the escape of evaporated moisture from the plant food solutions, as the low records of humidity during the experiments indicate. Plants growing in pots enclosed in cellophane proved relatively inefficient, for in preliminary tests with them the R.H. could not be reduced below 15%, and it was often considerably higher.

The host plant *Coleus*, a fortunate choice in the original experiments in saturated air, proved exceptionally useful for the work at low humidity described here. Even at the end of an experiment lasting some weeks, and in spite of the presence on them of the mealy bugs, they were still growing vigorously. Cuttings proved superior to whole plants because the roots, however carefully washed, were liable quickly to foul the nutrient solution, thus necessitating very frequent changes of the latter. The cut ends rapidly grew fringes of adventitious roots, which proved functionally quite adequate, and a change of food solution was only necessary every five days. In the tubing connecting the apparatus with the filter pump was inserted a dewpoint hygrometer of the usual type, which consisted of a silvered thimble enclosed in a glass cylinder, through which air was drawn after it had passed through the jars containing the plants and insects.

A thermometer bent at right angles and fitted into the interior of the thimble enabled the temperature to be read at which dew began to be deposited. Ether was used as the temperature depressant, and cooling air was forced into it by means of a rubber bulb operated by hand. The temperature of the water-bath was maintained at a steady  $23 \pm 0.10^\circ \text{C.}$  by means of a gas thermostat assisted by an automatic stirrer, and the accurate thermostatic control of the air current was ensured by means of a coil (fig. 1 C.T.) immersed in the water-bath. The latter was also encased in asbestos.

The current of air passing through the apparatus was maintained at a speed of 6-4-0.30 cms. per sec., which was just sufficiently fast to bring about a continuous change of air in the glass jars, and the gradual increase of humidity which would have accumulated principally from the transpiring plants was thereby prevented. A series of four small tubes, each containing a small quantity of high vacuum oil (fig. 1 H.V.) through which the current of air had to pass, made it possible to observe at a glance whether the apparatus was working efficiently.

The inflowing air passed through three Winchester bottles filled with calcium chloride, and before entering the apparatus was completely dry, as no dew-point could be obtained from it by means of the dewpoint hygrometer. The passage of the dry air current was necessary for about 24 hours before R.H.'s below 10% could be obtained from the outflowing air. Newly moulted virgin females were then placed on the plants and kept enclosed in isolation from males. Although a certain mortality always occurs consequent upon some of the insects wandering off their host plants and failing to become re-established, the majority remained thereon, feeding satisfactorily for the duration of an experiment. The only external effect their subjection to very low humidity appeared to have was an alteration in the appearance of the pattern of the waxy coat, owing to the removal therefrom of what was probably hygroscopic moisture.

In the experiments in saturated air already referred to, 36 females were kept at a mean temperature of 23° C. for 42 days before fertilisation, and the mean of the resulting family sex ratios was 180.89  $\pm$  6.20  $\overline{55}$  per 100  $\overline{77}$ , as compared with the mean of 101.62  $\pm$  1.54  $\overline{55}$  per 100  $\overline{77}$  from a series of 47 females, maintained in comparable conditions, but fertilised at the normal time.

In the following experiments the females, instead of being maintained in saturated air, were kept in a very dry environment during the maturation and ageing of their ova.

In the first experiment 35 newly moulted virgin females were maintained on the plants in the apparatus at a temperature of 23  $\pm$  0.10° C. for 42 days.

Dewpoint determinations of the humidity of the out-flowing air were made every twenty-four hours, and the following is a record of them for the duration of the experiment. Dewpoints as low as -14° C. were recorded.

Date : November	26	27	28	29	30		
R.H. % :	9.60 +	6.39 +	6.89 -	3.74 -	2.48 -		
Date : December	1	2	3	4	5	6	7
R.H. % :	3.45 -	5.98 -	2.14 -	7.22 +	7.38 +	2.80 +	3.54 +
Date : December	8	9	10	11	12	13	14
R.H. % :	4.85 -	5.72 +	5.73 -	4.80 +	4.17 -	3.24 -	5.71 -
Date : December	15	16	17	18	19	20	
R.H. % :	2.47 +	3.22 +	2.46 +	1.88 +	3.62 +	3.89 -	
Date : December	21	22	23	24	25	26	
R.H. % :	4.44 +	5.10 +	2.24 +	6.37 -	5.12 -	5.80	
Date : December	27	28	29	30	31		
R.H. % :	7.82 +	4.22 -	3.78 -	4.35 -	4.72 -		
Date : January	1	2	3	4	5	6	7
R.H. % :	5.87 +	6.22 -	5.56 +	4.44 +	3.89 -	2.28 -	4.47 +



This series of determinations of the R.H. of the outflowing air gives a mean for the period of  $\frac{200.04}{42} = 4.76 + \%$ . Twenty-four hours before the end of the experimental period of over-ageing of the ova a large number of adult males were liberated in the apparatus, and these ensured the speedy fertilisation of nearly all the females.

The latter were then removed and placed each on separate *Coleus* plants, and enclosed under cellophane-capped lamp-glasses, and their progeny reared and sexed in the manner already described in a previous paper.

In the following table is set out the series of family sex ratios obtained from this experiment.

TABLE 1.

A series of thirty-five family sex ratios from females of *P. citri* which had been over-aged for 42 days in dry air.

No. of ♀	♂♂	♀♀	Total Progeny	Family Sex Ratios
1	224	80	304	280.00
2	148	54	202	274.07 +
3	251	98	349	256.12 +
4	175	70	245	250.00
5	119	48	167	247.92 —
6	192	80	272	240.00
7	183	77	260	237.66 +
8	143	61	204	234.42 +
9	100	48	148	208.33 +
10	66	32	98	206.25 +
11	180	96	276	187.50
12	120	72	192	166.67 —
13	85	60	145	141.67 —
14	170	124	294	137.10 —
15	90	70	160	128.57 +
16	66	52	118	126.92 +
17	192	152	344	126.92 +
18	157	128	285	122.66 —
19	168	140	308	120.00
20	168	140	308	120.00
21	210	176	386	119.32 —
22	124	108	232	114.81 +
23	81	72	153	112.50
24	97	88	165	110.23 —
25	60	56	116	107.14 +
26	79	76	155	103.75 —
27	108	104	212	103.85 —
28	147	144	291	102.08 +
29	72	72	144	100.00
30	167	168	335	99.41 +
31	104	108	212	96.30 —
32	96	100	196	96.00
33	80	85	165	94.12 —
34	52	56	108	92.86 —
35	66	72	138	91.67 —
	4540	3167	7707	5356.41

The mean ratio of the series =  $\frac{5356.41}{35} = 153.04 \pm 10.51$  ♂♂ per 100 ♀♀.

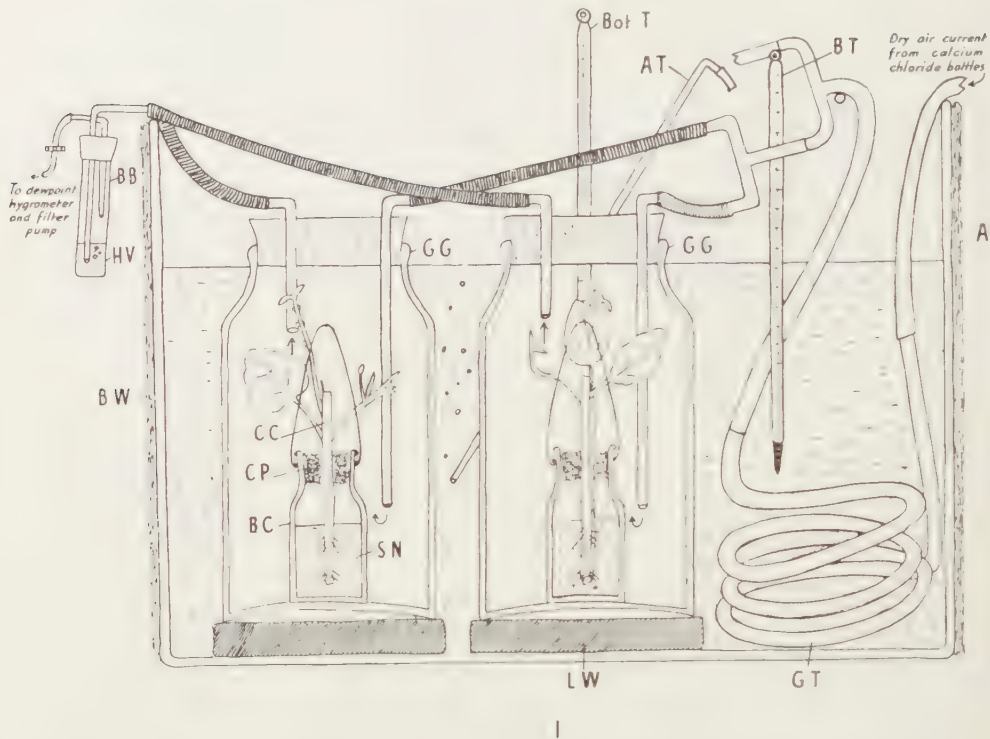


FIG. 1.—A.S. Asbestos casing. A.T. Automatic stirrer. B.B. Bubbler. B.C. Bottle containing plant nutrient solution. B.T. Water bath thermometer. B.W. Water bath. Bot. T. Thermometer in glass jar. C.C. Cuttings of *Coleus*. C.P. Cotton plug. C.T. Thermostatic coil. G.G. Glass jar. H.V. High Vacuum oil. L.W. Lead weight. S.N. Sach's nutrient solution.

The experiment was repeated, and the following is the record of the daily determinations of the R.H. of the outflowing air throughout its duration.

Date :	May	10	11	12	13	14	15	16
R.H. % :		7.23 +	5.84 —	5.87 +	3.46 —	2.22 +	2.47 —	2.76 —
Date :	May	17	18	19	20	21	22	23
R.H. % :		2.67 —	2.29 —	4.19 +	3.75 +	3.45 —	2.38 +	1.30 —
Date :	May	24	25	26	27	28	29	30
R.H. % :		3.02 +	5.72 +	7.42 +	4.58 +	6.21 —	2.72 —	2.19 —
Date :	May	31	June	1	2	3	4	5
R.H. % :		1.97 +		3.16 +	3.16 —	2.22 +	5.83 —	7.28 —
Date :	June	6	7	8	9	10	11	12
R.H. % :		3.05 +	2.07 —	3.94 +	4.98 +	5.77 +	4.36 —	3.65 +
Date :	June	13	14	15	16	17	18	
R.H. % :		6.22 —	5.21 —	2.42 +	2.48 +	4.75 +	5.23 —	
Date :	June	19	20					
R.H. % :		4.39 +	6.24 +					

The mean R.H. of the outflowing air for the period of the experiment  
 $= \frac{170.12}{42} = 4.05 + \%$ .

The sex ratios of 37 females were successfully obtained in the second experiment, these are given in Table 2.

TABLE 2.

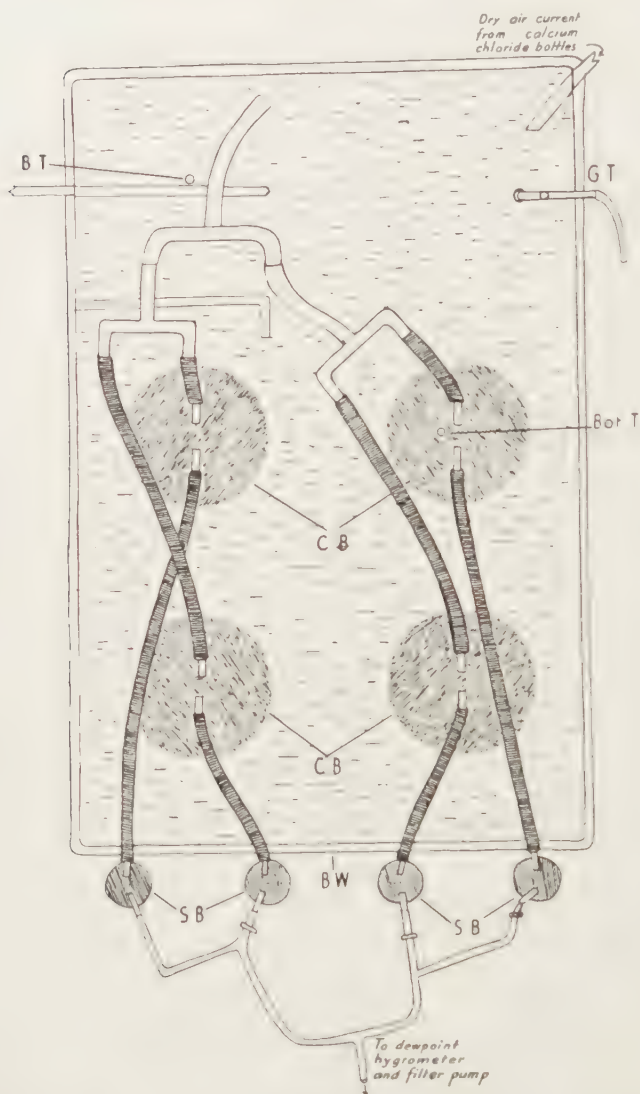
A series of thirty-seven family sex ratios from females which had been over-aged for 42 days in dry air.

No. of ♀	♂♂	♀♀	Total Progeny	Family Sex Ratios
1	229	83	312	275.90 +
2	265	97	362	273.20 —
3	160	59	219	271.19 —
4	167	62	229	269.35 +
5	118	45	163	262.22 +
6	93	37	130	251.35 +
7	153	61	214	250.82 —
8	80	36	116	222.22 +
9	46	22	68	209.09 +
10	125	62	187	201.61 +
11	94	48	142	195.83 +
12	149	80	229	186.25
13	84	46	130	182.61 —
14	123	68	191	180.88
15	89	50	139	178.00
16	172	96	268	179.17 —
17	208	128	336	162.50
18	49	31	80	158.06 +
19	160	104	264	153.85 —
20	106	72	178	147.22 +
21	73	50	123	146.00
22	25	18	43	138.89 —
23	156	120	276	130.00
24	68	56	124	121.43 —
25	113	94	207	120.21
26	215	180	395	119.44 +
27	68	60	128	113.33 +
28	74	68	142	108.82 +
29	204	192	396	106.25
30	61	58	119	105.17 +
31	116	112	228	103.57 +
32	116	120	236	96.67 —
33	65	68	133	95.59 —
34	90	96	186	93.75
35	132	144	276	91.67 —
36	76	88	164	86.36 +
37	92	114	206	85.95 —
	4414	2925	7339	6074.42

The mean ratio for the series  $= \frac{6074.42}{37} = 164.17 \pm 10.379$  ♂♂ per 100 ♀♀.

Plant-sucking insects are always supplied with an abundance of very dilute food in the form of plant-cell sap, and in contrast to the majority of insects they are concerned less with the conservation of moisture than with the elimination of surplus quantities of it. Recent research has made it appear probable





2

FIG. 2.—B.W. Water bath. Bot.T. Thermometer in glass jar. B.T. Bath thermometer. C.B. Cork bungs. G.T. Gas thermostat. S.B. Stoppers of bubblers.

that at moderate temperatures the evaporation of water from insects is almost entirely through the spiracles, and there does not appear to be any valid reason for suspecting that a different arrangement obtains in *Pseudococcus*. Its derm, though thin, is tough, and in the species here under consideration is covered dorsally with a relatively thick coating of wax. On the anus no doubt devolves the duty of evacuating the large excess of moisture imbibed with the food, and not absorbed into the system. It is possible, however, that the characteristic anal excretion of this insect, mainly a very dilute solution of several sugars, may imply that it contains important quantities of water of excretion.

Apart from the anus, the only apertures through which an appreciable amount of moisture could escape are four very minute spiracles situated on the ventral aspect of the thorax. These spiracles are normally in fairly close apposition to the plant surface, which in situations where these insects commonly feed is actively transpiring, and close to which the saturation deficiency may be quite small. Hence a humidity gradient almost invariably exists between the plant surface and the spiracular orifices of *Pseudococcus*, and although the R.H.'s obtained from the air passing out of the apparatus may suggest that the saturation deficiency within is very large, the actual saturation deficiency in the region of the insects' spiracles is less, and probably appreciably less.

However, this paper is not directly concerned with the manner in which moisture is eliminated by *Pseudococcus*, nor with the measurement of increasing quantities eliminated because of their subjection to drier environments. The question which this paper attempts to answer is whether the subjection of adult virgin females to widely different degrees of environmental humidity during the maturation of their ova and a subsequent period of over-ageing would be productive of significant variations in their sex ratios.

The two series of thirty-five and thirty-seven family sex ratios obtained from the experiments in dry air produced mean ratios of  $153.04 \pm 10.51$  ♂♂ per 100 ♀♀ and  $164.17 \pm 10.379$  ♂♂ per 100 ♀♀ respectively, and compared with the mean sex ratio of  $180.89 \pm 6.20$  ♂♂ per 100 ♀♀ from the experiment in saturated air, they give statistically significant variations which show that drier environments favour the production of females in *Pseudococcus*. The differences, however, are not sufficiently substantial to warrant the assumption that the humidity of the environment can be regarded as an important agent in the production of the higher proportion of males in sex ratios from over-aged ova in *Pseudococcus*.

#### Summary.

(1) The humidity of the environment is not the decisive factor in the production of the higher proportion of males obtained in sex ratios from over-aged ova in *Pseudococcus citri* Risso.

The mean of the family sex ratios of females kept in dry air during the maturation of their ova and a subsequent period of over-ageing gave a statistically significant larger proportion of females when compared with the mean ratio from females kept in saturated air during a corresponding period at the same temperature.

Whilst the differences are sufficiently large to show that drier environments favour the production of females in *Pseudococcus*, they are not large enough to suggest that the humidity of the environment is the principal factor producing alterations in sex ratios by over-ageing the ova.

(2) From two experiments two series of thirty-five and thirty-seven family sex ratios obtained from females maintained in dry air during the maturation and ageing of their ova (a period of 42 days) gave mean ratios of  $153.04 \pm 10.51$  ♂♂ per 100 ♀♀ and  $164.17 \pm 10.379$  ♂♂ per 100 ♀♀ respectively. These mean ratios are compared with the mean ratio of  $180.89 \pm 6.20$  ♂♂ per 100 ♀♀ obtained from the sex ratios of thirty-six females maintained in saturated air during a corresponding period.

#### REFERENCES.

1. JAMES, H. C., 1937, Sex ratios and the Status of the Male in *Pseudococcinae* (Hem. Coccidae). *Bull. ent. Res.*, **28** : 429-461.
2. RAMSAY, J. A., 1935, Methods of Measuring the Evaporation of Water from Animals. *J. exp. Biol.*, **12** : 355-372, 5 figs.

## OBSERVATIONS ON BUTTERFLIES, JULY 1937, IN SOUTHERN FRANCE

By J. A. SIMES, O.B.E., F.R.E.S.

1. *Successful resistance of Eumenis circe L. to disturbance by high wind.*—On the 17th July, 1937, I made a rather curious observation on a number of examples of the southern "grayling" butterfly *Eumenis circe* L. at La Ste. Baume, Var. France. This locality lies about 2000 feet above sea level on a plateau which is bounded southwards by a wall of rock rising about 1000 feet above the level of the plain. The wall is ascended in two or three places by zigzag paths, and when the top of the wall is reached it is found that the country slopes away gently southwards towards the sea. There is a wonderful view from the top of the cliff, and it was mainly for that reason that I climbed it. Looking towards the north-east one's eye wanders over a succession of pine-clad hills and ridges until it finally rests on the snowfields of great peaks fully 125 miles away. Standing on the cliff-edge, however, one could not fail to be impressed by the strong wind which was sweeping up the rock-wall from the plain below. Insects coming up the slope from a southerly direction were caught in the swirl as they neared the cliff-edge and swept upwards; and it was doubtless for the sake of the flies thus swept into space that the two species of swift *Cypselus apus* and *C. alpinus* raced to and fro along the brink. Butterflies were frequently caught in the swirl; and I was particularly interested in the "airmanship" of *Eumenis circe* when thus overtaken. Keeping its head pointing steadily downwards, it kept its wings half-opened and rigid, and thus converted itself more or less into a shuttlecock. The half-opened wings offered resistance to the air above, while to the current from below there was presented an inverted cone on which the effect was small. I watched several of the butterflies as they became involved in the current, and they all behaved in the same way. By avoiding any "panic" fluttering they were able to set a limit to their discomfiture and to regain control in a short time.

2. *Females of Dryas paphia drinking.*—On the 15th July I saw four females and one male of *Dryas paphia* drinking from moist earth at La Ste. Baume, Var. France. On the following afternoon several examples of both sexes visited the same spot. The moist patch was just inside a wood and was in sunlight quite a short time. As soon as the sunshine left the patch the butterflies abandoned it.

3. *Note on the Large Skipper butterfly*—*Ochlodes venata* = (*Augiades sylvanus*). The following observation on a male of *Ochlodes venata* (*Augiades sylvanus* the large Skipper butterfly) was made near Nans-les-Pins, Var, France, on the 14th July, 1937. The day was very hot; and after an hour or two spent in collecting in the afternoon I was glad to seek shade and a rest. Soon afterwards a male of *Ochlodes venata* alighted on my right fore-arm; and I watched it very closely for several minutes. The wings were held vertically over the back; the tip of the abdomen was depressed so as to be almost in contact with the surface of my arm; and the proboscis was extended below the ventral surface of the insect between the legs in such a way that its tip was almost in contact with the depressed tip of the abdomen. Almost immediately after it had alighted the insect deposited on my arm a minute globule



of a clear liquid from the depressed tip of the abdomen. The globule spread itself out somewhat and the proboscis reabsorbed the whole of the liquid. The process was repeated several times, the butterfly meanwhile walking about very slowly on my arm; and it was terminated only by my cautiously boxing the insect.

It seemed to me as I watched the insect that it must be obtaining some saline secretion from the surface of the arm and that the globules of fluid dropped from the tip of its abdomen served the purpose of making the salts soluble and thus capable of assimilation by the butterfly. The fact that the butterfly constantly moved about on the surface of the arm seems to me to prove that it was in quest of some substance which it found there but which was speedily exhausted in any one spot.

Sir Edward Poulton had written to say that this was the second occasion on which *Ochlodes venata* (*Angiades sylvanus*) had been observed extruding moisture upon human skin and then absorbing the liquid by means of its proboscis. The earlier record, also of a male *sylvanus*, was that of Dr. O. W. Richards, in July 1930, at Ferleiten Salzburg, Austria. It is recorded in 1930, *Proc. ent. Soc. Lond.*, 5: 88, where references are given to the similar behaviour of other HESPERIDAE, only a single mention being made of butterflies belonging to another group (LYCAENIDAE).

## NOTE ON PUPATION OF *PARARGE MAERA* L.

By J. A. SIMES, O.B.E., F.R.E.S.

IN July 1936 I brought home to England, from Pertisau, Austria, some living females of *Pararge macra*, and obtained from them a number of ova. The larvae were fed on grass growing in flower-pots. They came through the winter safely, but presented no points of special interest until the time for pupation arrived. In nature the pupa of this species is suspended from a moss-covered wall or rock; and my larvae were obviously worried by the absence of any wall or rock of that kind. Each one in turn searched widely for the traditional pupating site of its race, and failed to find it. In the end they all had to make the best of a bad job by attaching themselves to the outside of the flower-pot, just below the thickened lip, this being the only "rock" they could find. Two of the pupae were of a distinctly dark green, but all the rest were of the normal grass-green colour. They were, of course, very conspicuous objects on the red flower-pot.

FURTHER OBSERVATIONS ON THE PSEUDOCOPULATION OF THE  
MALE *LISSOPIMPLA SEMIPUNCTATA* KIRBY (HYMENOPTERA  
PARASITICA) WITH THE AUSTRALIAN ORCHID,  
*CRYPTOSTYLIS LEPTOCHILA* F. v. M.

By MRS. EDITH COLEMAN.

WITH PLATE I.

Communicated, with an Introductory Note, by Sir EDWARD POULTON.

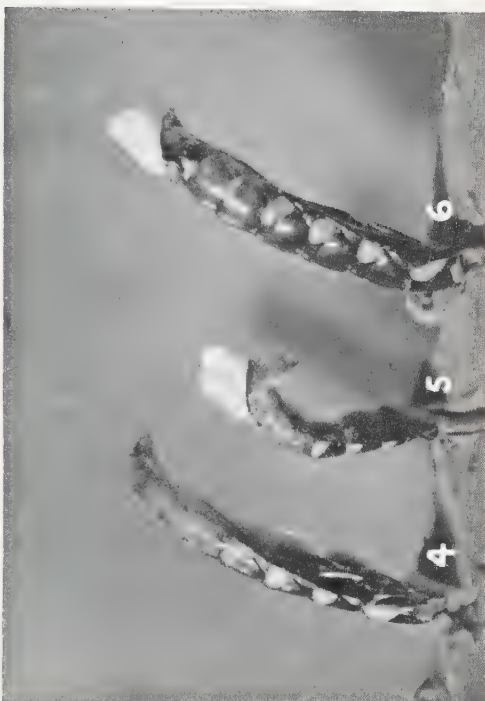
[THE observations here recorded are quoted from three letters written to me by Mrs. Coleman, between 3 September and 4 December, 1937. They provide a very interesting addition to the subject treated by the authoress in our 1928, *Transactions*, 76:533-9\*; in 1930-1, *Proceedings*, 5:15 and 114; 1931, *Proceedings*, 6:22-4; and in papers from the *Victorian Naturalist* kindly presented by her to our library. Pseudocopulation with the orchid *Cryptostylis leptochila* is proved by photographs here reproduced to be attended by protrusion of the male claspers, as in normal copulation, and also to be repeatedly performed as shown by the cluster of pollinia attached to the Ichneumonid's abdomen, well seen in figs. 2, 3. A recent paper by Oakes Ames gives a full and interesting account of the "Pollination of Orchids through Pseudocopulation,"† as observed by Monsieur A. Pouyanne in Algeria, Col. M. J. Godfery at Hyères and Mrs. Coleman in Australia. The paper includes a very full Bibliography. A brief account of Pouyanne's and Godfery's observations is also given in our 1927, *Proceedings*, 2:31-3. E. B. P.]

Walsham, Blackburn, Victoria, Australia.

3 September, 1937. I have always felt that I could not claim to have completed my notes on the pollination, by pseudocopulation, of *Cryptostylis* until I had shown clearly that the attraction for the male Ichneumonid is a sexual one. In a series of photographs, taken for me by Mr. O. H. Coulson, of material I had sent him, he shows very clearly that the claspers are fully extruded. I thought you would like to have prints of these (figs. 1-3). They were taken by electric light, and the highlights on the polished abdomen made the operation difficult. Mr. Coulson wrote, 8 April, 1937, "The only way I could show the extended claspers was to photograph the abdomen only. Fig. 1, with the mass of pollen hiding the claspers, was difficult to pose; so was one of the others; and in trying various ways the pollen was knocked about, in addition to what it suffered through the post." Figs. 2 and 3, in which the pollen masses are shown intact, I took into town myself and handed them safely to Mr. Coulson.

\* "Pollination of an Australian orchid by the male Ichneumonid *Lissopimpla semipunctata* Kirby," with an Introductory Note by E. B. Poulton and an Appendix by A. M. Lea. Plates XXIII, XXIV and one text-fig.

† Botanical Museum Leaflets, Harvard University, Cambridge, Mass., U.S.A., 1937: vol. 5, No. 1, pp. 1-26, two plates and illustrations on pp. 5 and 11, repeated with explanations on pp. 22, 23 and 24, 25, respectively.



PHOTO, O. H. COULSON.  
Abdomina of male Australian Ichneumonid, *Lissopimpla semipunctata*: figs. 1, 2, 3, 5, shewing extruded claspers and attached pollinia,  
ENGRAVED BY STAR ILLUSTRATION, LONDON.





15 November, 1937.—As you see from the pollinia shown in the photographs, the ichneumons visit a number of flowers, which suggests that they must obtain some satisfaction.

4 December, 1937.—The photographs shown in figs. 1-3 were all of *Lissopimpla semipunctata* which I had lifted with my thumb and finger out of flowers of the orchid *Cryptostylis leptochila* (during pseudocopulation) in January 1937 and sent to Mr. Coulson. The claspers are extruded *when withdrawn from the flower* and remain extruded when the insect is placed in the killing-bottle. (I always use chloroform first—to ensure an easy death.) Where the insects do not seem eager one may take them at the wrong moment and find that the claspers are not extruded, but almost always they *are* extruded.

Figs. 4-6 from the enclosed photograph, also taken by Mr. Coulson, will illustrate the different conditions:—

Fig. 4 is the abdomen of an insect which appeared to be merely philandering and possibly not mature; yet attracted by some subtle charm to the flowers.

Fig. 5 shows clearly the extruded claspers.

In fig. 6, though taken from the orchid in the copulatory position, the claspers are not extruded, nor *is the abdomen curved* as is usual during copulation.

The abdomen is curved when the male copulates with a real, not imaginary, female, as I noted when one was enclosed in a jar with seven males, all of which tried to copulate with her, though they seemed to prefer the flowers (*Cryptostylis leptochila*) which were also in the jar.

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#### BOOK NOTICE.

*Faune de France*. 32. Ixodoidés, par G. SENEVET. Paris, 1937 (P. Lechevalier). Pp. 101, 67 figs. 50 frs.

This part of the well-known *Faune de France* series is devoted to the Ticks, a group of great medical, veterinary, and economic importance. This importance is recognised by the author in not restricting his work to those species actually reported from France, but by including those recorded from Britain, Belgium, Germany, Switzerland, Italy, Spain and North Africa.

The introduction deals with general characters of ticks, their morphology, biology and classification, and this is succeeded by the main part of the work, devoted to a systematic treatment of the species, with notes on hosts of each species.

Keys are given for genera and species, and line-figures of almost all the 49 species dealt with.

*PHIBALAPTERYX POLYGRAMMATA* (BKH.) VAR.  
*CONJUNCTARIA*

By G. R. BALDOCK, F.R.E.S.

NINE specimens of this extinct insect taken by H. Doubleday in 1851 were exhibited at the *Conversazione* on 19th January, 1938.

AUSTRIAN SPECIMENS OF *PIERIS BRYONIAE* OCHS. 1808

By Dr. K. JORDAN, F.R.E.S.

MESSRS. MÜLLER AND KAUTZ of Vienna have investigated the status of *P. bryoniae* by extensive breeding and observation in the field and come to the conclusion that *P. bryoniae* and *P. napi* L. are distinct species. They found, moreover, that *P. bryoniae* consisted in Austria of three subspecies: one occurring at high altitudes, the second north of the Alps up to 3000 ft., and the third south of the Alps up to the same level. A monograph will be issued in the near future as a separate publication, illustrated by 16 coloured plates. Many British entomologists have collected these butterflies in the Alps, and it would be of interest to know whether the material from more western districts of the Alps than is described in Messrs. Müller and Kautz's book confirms the conclusions of the authors.

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BOOK NOTICE.

*Die Staaten der Ameisen.* Von Dr. W. GOETSCH (Verständliche Wissenschaft, Band 33). Berlin, 1937 (Verlag J. Springer). pp. vii + 159, 84 figs. Rmk. 4.80, bound.

This is a popular account of ants written, largely on personal observation, by the Director of the Zoological Museum at Breslau.

It deals with all phases and all stages of ant life. Chapters are devoted to fungus-gardens and storage; to guests and enemies of ants; to war and hunting; to psychology and intelligence; to recognition of the sexes and heredity. A short list of works of reference is given and finally hints for combating ants in houses. The book is not restricted to common European ants, and its size permits it to be carried easily in the pocket.



## BOOK NOTICES.

*Source Book of Biological Terms.* By A. L. MELANDER. New York. (The College of the City of New York.) 1937. pp. v + 157.

This book by Dr. Melander is the successor to a preliminary list of biological terms issued for distribution to students in the Department of Biology at the City College of New York. The success of that booklet caused it to go out of print, and encouraged the author to elaborate his work to its present size and to make it available to all students of Biology.

Pages 1-60 are devoted to a discussion of the origins and development of names and their pronunciation, and include a table of the more usual biological suffixes and the Greek alphabet with its English equivalent. This is followed by the main part of the work, entitled *Alphabetical list of the Components of Biological vocabulary*.

*Animal Treasure.* By IVAN T. SANDERSON. Macmillan & Co., London. 1937. pp. 325, 32 figs. Price 12s. 6d.

This handsome book comprises 16 chapters arranged in 6 "parts" as follows: 1. Unusual vermin, 2. The great forest, 3. The flying continent, 4. Misty mountains, 5. The great waters, 6. All over the place. It is written by a young naturalist, and deals with animal life of the Cameroons, West Africa. The expedition, on which the material for this book was collected, was undertaken to study animal behaviour in the field and under as natural conditions as was possible. The author endeavoured to understand the reactions of wild animals to events affecting them, and made a great endeavour to appreciate the "point of view" of the animal observed. That he was often successful is proved by the fact that he was sometimes able to foretell an animal's reaction to a given event.

The illustrations are remarkable, and are all of originals made by the author.

*Neue Untersuchungen über die fossilen Insekten mit Ergänzungen und Nachträgen sowie Ausblicken auf phylogenetische, palaeogeographische und allgemein biologische Probleme.* I Teil. Von A. HANDLIRSCH†. Naturhistorisches Museum, Wien. pp. iii + 140. 1937. [Ann. Naturhist. Museum, Wien. 48.]

This posthumous work of Dr. Handlirsch is in the nature of a supplement to his monumental work on fossil insects published in 1908.

Its chapters deal with the completeness and the incompleteness of paleontological material; Trilobites as the ancestors of all Arthropods; The ancestry of insects; The wings of insects; Segments and limbs; The tracheal system and segmental organs; The insect fauna of coal formations; The permian insect fauna and a bibliography of palaeozoic insects.

Its publication in separate form from that in which it first appeared in the *Annalen* is a great convenience to those wishing to place it beside the main work.

## BOOK NOTICES.

*How Animals Behave.* By H. G. WELLS, J. HUXLEY, and G. P. WELLS. (The seventh volume in the *Science of Life* Series.) London, Cassell & Co., Ltd. 1937. pp. x + 263, 44 figs. Price 4s.

This book is a popular account of animal behaviour. It contains chapters on: Rudiments of behaviour; How insects and other invertebrates behave; and The evolution of behaviour in vertebrates. The chapter on insects extends to over 70 pages, and has many illustrations by L. R. Brightwell.

The work appeared originally as "The Science of Life," now issued in nine volumes, each of which was originally a section of the larger work. By this means interested readers may obtain the part they need at a very reasonable price.

*The Observer's Book of British Butterflies.* Compiled by W. J. STOKOE, foreword by N. D. RILEY. London (F. Warne & Co., Ltd.). 2s. 6d. pp. 191, illust. (col.).

This little book is issued "at a popular price, suitable for carrying in the pocket, giving accurate illustrations," and is uniform with other volumes on birds and plants.

For each of the native species illustrations of all stages are given, those of the perfect insects being in colour, and all the figures are placed in the text. The size of the book is  $5\frac{3}{4} \times 3\frac{3}{4}$  inches, and it is strongly bound in green cloth. The main part of the work is stated to be based on South's well-known book, but the nomenclature has been brought up to date by the adoption of the names officially proposed by the Society.

*Catalogus Lepidopterorum regionis palaearcticae.* Editus ab O. BANG-HAAS. 8vo, Dresden. (Verlag Staudinger & Bang-Haas). Subscription price Mk.12.00. Lief. 1-6, pp. 1-95.

The well-known Staudinger *Catalogue*, so long a tool on the desk of Lepidopterists, is now to be replaced by the new catalogue here noticed.

The catalogue is to be issued in about 12 parts, each of 16 pages, and of which the first appeared in April 1937, and the sixth in October 1937. Lieferungen 1-6 contain the Rhopalocera (pp. 1-48) and the commencement of the Heterocera, the Bombyces and Sphinges being completed (pp. 49-95).

A departure is made from the earlier catalogue in that the present work gives in three columns the names of the insects catalogued, with their authors, and the price at which specimens may be supplied by Messrs. Staudinger and Bang-Haas. No bibliographical references are given other than general references to such works as Seitz, *Grossschmetterlinge der Erde* and the *Lepidopterorum Catalogus*.

## THE SWARMING OF THE MALES OF *VESPULA SYLVESTRIS* (SCOP.) AROUND A QUEEN

By R. G. C. C. SANDEMAN, F.R.E.S.

ON 1 August 1937, while on a collecting trip to Newport, Pembrokeshire, it was my good fortune to make an extremely interesting and unusual observation on the mating habits of the wasp *Vespula sylvestris* (Scop.).

Before describing what took place, it may be of general interest to say a few words on the habits of this species in my home county of Breconshire.

Although one of the "Tree Wasps," it never builds in trees or bushes in Breconshire, but almost invariably hangs its nest under an overhanging river bank or in some small hollow in a bank or slope and generally near a stream. Sometimes, however, it builds in old walls, but the former situation is more general. It is not nearly as common as the other wasps—being in fact rather scarce and in some years rare.

This species, in common with *V. norvegica* (Fab.) and *V. rufa* (Fab.), is an early nester and the nests produce males as early as the last week of July, and the nests are abandoned and deserted long before those of *V. vulgaris* (L.) and *V. germanica* (Fab.) have reached full strength.

I will now describe what I saw of the mating habits of this species in Newport.

About 11.30 a.m., whilst wandering along the high cliff tops to the north, known as Morfa Headland, my attention was attracted by large numbers of wasps which were flying around several of the gorse-bushes. The ground here slopes to the south and is covered with a profusion of gorse-bushes, bell-heather and bracken. The day was cloudless and very hot with a fresh S.E. breeze blowing up the slopes.

The wasps were hovering low over the bushes and then alighting on the top, and at first I thought that there must be nests in them. On investigation, however, I was surprised to find that the insects were males of *V. sylvestris*.

Next came the surprising discovery of a queen seated upon the bush and completely surrounded by a small swarm of males. There were about 15 around her in a compact mass. Those in actual contact with her were clinging to her and clasping her with their legs, whilst a layer of others crawled about over them and formed a compact ball-like mass. It was only by moving them apart by means of a small twig that I disclosed the queen in the centre of the mass of males, and at first I was under the impression that the insects were assembled around something that they were eating. All the time others kept alighting on the bush and flying around. There must have been quite 50 around this one small stunted gorse-bush and the same thing was taking place on three other bushes nearby, where I found three more queens *in cop.* but not surrounded by such a swarm as was the first.

Having no means to take them back alive, I got them into my killing-bottle by rolling them in together with the surrounding swarm of males. They remained clinging around the queen till the cyanide took effect. When they were dead I took the queen and laid her again upon the gorse-bush in as life-like a position as possible to see what took place.

Almost at once a male alighted near her and crawling to her he got upon her back. Sitting upon her and gently nibbling at the base of the antennae, it arched its abdomen and rocked from side to side, at the same time endeavouring to get its abdomen under her. This continued for about 15 seconds, after



which it evidently sensed that something was wrong and crawled from her. Other males came and did the same thing. In every case they got upon the queen's back and endeavoured to stimulate her by gently nibbling at the base of her antennae and thorax, then finding no response crawled away. During some quarter of an hour no fewer than 20 came to the queen, whilst dozens were flying around the bush. They all came up-wind and the whole affair reminded me of assembling by moths.

I next turned my attention to the other three bushes. Upon each of these was a queen surrounded by a group of males. Each of these queens was *in cop*, and a small assembly of males crawling around and over her in eager excitement, but not in such numbers as on the first bush.

I finally got them all into the bottle and then replaced the dead queens upon the same spot on the bushes. The same thing took place as in the first case. It was astonishing that for a considerable time the incoming males did not seem to find anything abnormal about the dead queens, and continued to alight upon them and attempt to mate.

I watched this most unusual and interesting sight for fully an hour. I then made a careful search for more queens but found none, and the whole affair was evidently limited to these four bushes and to an area of some 30 yards.

The gorse-bushes chosen by the queens were thick, stunted, and wind-blown bushes about four feet in height. They were all in full and brilliant sunshine.

On reaching my hotel I made a careful examination of the four queens and the 30 males taken. They were, as far as one could make out, all typical specimens of *V. sylvestris* as regards markings, size, colour and general external characters.

In conclusion, it appears from this observation that the queens of this species after emerging from the nest before hibernation, seek out a position on a gorse-bush on some hot sunny day and are there visited by the males in large numbers. I am, of course, referring to the particular locality in which I made the observations.

As to the times of emergence of the future queens and the males from the nest, and the general habits of this and the other species of social wasps, I have had nests under close observation for some seasons past and have amassed copious notes which I hope to give in other communications in the future.

Dr. C. H. ANDREWES, who was present at the meeting to which the above communication was made, contributed the following observations.

In August 1936, I made some observations similar to those described by Mr. Sandeman. Curiously enough they were made only six or seven miles from Newport, Pembrokeshire, where his were made. I went up the Prescelly Mountain, the only considerable height in Pembrokeshire, on a still, cloudy day in the middle of August, and on the mountain-top noticed large numbers of wasps of the genus *Vespa*. Closer observation revealed that these consisted entirely of queens and males, numbers of males being congregated around each queen. Some clusters of about a dozen wasps were observed—all males with the exception of one queen in the centre. There were possibly fifty queens altogether and of course many more males. Not knowing that this congregation of wasps was unusual, I neglected to secure any specimens and thus cannot be certain what species of *Vespa* was concerned.

INFECTION OF *PLODIA INTERPUNCTELLA* (HB.) (LEPIDOPTERA, PHYCITIDAE) WITH A SCHIZOGREGARINE, *MATTESIA DISPORA* NAVILLE

By A. J. MUSGRAVE, A.R.C.S., B.Sc.

(Department of Zoology and Applied Entomology, Imperial College, London),

and

D. L. MACKINNON, D.Sc.

(Department of Zoology, King's College, London.)

Communicated by Dr. O. W. RICHARDS, F.R.E.S.

WHILE examining sections of a larva from a culture of *Plodia interpunctella* (Hb.), we found the fat-body laden with spores of a parasitic Protozoan (fig. a), and numerous spindle-shaped protoplasmic bodies (fig. b) were observed in the haemocoel. Larvae from a fast-dying culture were then examined, and the same parasite was found in them abundantly. Sections of the fat-body, specially fixed and stained for the purpose, were studied in detail. So far as morphological criteria go, the organism appears to be *Mattesia dispora* as described by Naville from larvae of *Ephestia kühniella* Zeller. Whether the species is really identical with Naville's we hope to test by trying to infect larvae of *Ephestia* from food from an infected *Plodia* culture.

*Mattesia dispora* is a schizogregarine, the asexual and sexual phases of which were very fully studied by Naville (1930) from the fat-body of larvae of *Ephestia kühniella* collected from a flour mill near Marburg.\* Schizonts of two kinds occur. One kind is said to give rise to further schizonts, the other kind to gamonts. When compared with other schizogregarines of insects, the most characteristic feature of *Mattesia* is that the gametocyst produces two octozoic sporocysts: according to Naville these measure  $14 \times 7.5 \mu$ .† The sporocysts in our *Plodia interpunctella* were slightly smaller. The largest one measured was  $13.5 \times 8 \mu$ , and the average measurement was  $11 \times 6 \mu$ . The dimensions of all other stages corresponded exactly with those given for *Mattesia dispora*. Naville states that the sporocysts escape from the fat-body into the haemocoel and may actually hatch there, the sporozoites then invading fresh fat-body tissue. If this view is correct, then multiplication of the parasite within the one host is due not only to schizogony but also to liberation of sexually-produced offspring. We are unable to say whether the mobile, spindle-shaped gregarinulae ( $10-15 \mu \times 1-1.5 \mu$ ) which swarm in the haemocoel of infected *Plodia* larvae are merozoites only or a mixture of merozoites and sporozoites: in support of Naville's view we record having observed a number of empty sporocysts among the full ones.

The organism seems to be highly pathogenic. Our observations suggest

\* Mattes (1927) recorded a monosporous schizogregarine, *Ophryocystis*, also from the fat-body of *Ephestia kühniella* larvae. The sporozoan mentioned by White (1927) as destroying whole cultures of *Ephestia kühniella* may have been Mattes' *Ophryocystis* or *Mattesia dispora* or, possibly, a microsporidian.

† It should be impossible to confuse *Mattesia* sporocysts with the spores of microsporidia, which would seldom be more than half this size and which, under suitable stimulus, would evert the characteristic thread from the terminal polar capsule.



that it may cause complete or partial destruction of *Plodia* cultures.\* Our infected cultures had been kept for some time at laboratory temperature in a rather dry atmosphere. Possibly these conditions increase the susceptibility of the insect to attack.

The natural assumption is that the larvae are infected by ingesting the spores in contaminated food. Naville was unable to find any stages of *Mattesia* in the gut of his infected *Ephestia* larvae, and he suggested that Ichneumonid or Braconid parasites might act as vectors: his Marburg larvae were heavily parasitised by an Ichneumonid. Our cultures appeared to be free from Hymenoptera, and mites were rarely seen. Probably *Mattesia* spores escape from the disintegrated bodies of infected larvae. Our observations suggest that *Mattesia* also occurs in the bodies of pupae and adults of *Plodia*. We have not examined eggs.

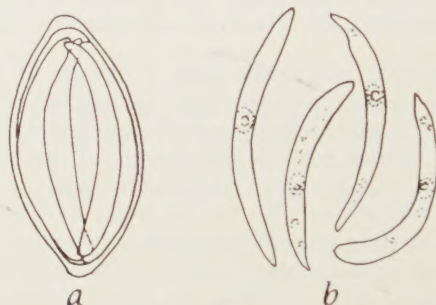


FIG. 1.—*Mattesia dispора* Naville from *Plodia interpunctella*, a. sporocyst, b. gregarinulae.  $\times$  c. 3000. Free-hand sketches of living stages from the haemocoel.

We are unable to suggest any method to remedy infection. There are no characteristic external symptoms by which the presence of the parasite may be detected. To prevent infection we suggest the following measures. Destroy all infected cultures; avoid overcrowding in cultures; breed only one generation of moths on one sample of food (cf. Mansbridge, 1933); breed the insects at optimum temperature and humidity. Sterilisation at high temperatures might kill the spores in the food, but would probably upset its vitamin content.

#### LITERATURE CITED.

- MANSBRIDGE, G. H., 1933, The breeding of *Ephestia kühniella* Zeller in large numbers for experimental work. *Ann. appl. Biol.*, **20** : 771-774.
- MATTES, O., 1927, Parasitäre Krankheiten der Mehlmottenlarven und Versuche über ihre Verwendbarkeit als biologisches Bekämpfungsmittel. *S.B. Ges. ges. Naturw. Marburg*, **62** : 381-417, 1 pl., 7 figs.
- NAVILLE, A., 1930, Recherches cytologiques sur les Schizogregarines. I. Le cycle évolutif de *Mattesia dispора* n.g., n.sp. *Z. Zellforsch.*, **11** : 375-396, 1 pl., 2 figs.
- WHITE, G. F., 1927, A protozoan and bacterial disease of *Ephestia kühniella* Zell. *Proc. ent. Soc. Wash.*, **29** : 147.

\* A cephaline gregarine was observed in the gut of larvae in two unhealthy cultures, but we do not hold this in any way responsible for the condition.



# PUBLICATIONS

The Publications of the Royal Entomological Society are *Transactions* and *Proceedings*.

The *Transactions* form an annual volume, each paper in the volume being issued as a separate part. The parts are issued irregularly throughout the year.

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The Society is prepared to undertake the provision of a reasonable number of text figures. The original drawings for such figures must be supplied by authors. Such drawings or groups of drawings must be drawn to a scale which will permit of their reduction to an area of dimensions not exceeding  $7\frac{1}{2} \times 4\frac{3}{4}$ ". In the case of the *Proceedings Series A* and *Series B*, authors are required to pay for the necessary blocks for the provision of plates, half-tone and coloured work.

A uniform method is adopted for the citation of bibliographical references in the Society's publications as follows:

Smith, A., 1936, New species of Coccidae, *Proc. R. ent. Soc. Lond.* (B) **6** : 301-306, pl. 1.

—, 1936, New species of Coccidae, *Trans. R. ent. Soc. Lond.* **84** : 901-936.

Titles of periodicals cited are to be abbreviated in the manner indicated in the *World List of Scientific Periodicals*, 2nd edition, 1934.

Authors are entitled to receive 25 copies of their papers free of charge and may purchase additional copies provided that request be made before publication.

Papers offered for publication should be sent to the Secretary, Royal Entomological Society of London, at 41, *Queen's Gate, London, S.W.7*, and must be typewritten on one side of the paper only. Sufficient space must also be left between the lines for editorial corrections.

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Papers offered for publication in the *Transactions* are considered by the Publication Committee of the Society, which meets usually in the months of May and November. In order that papers may be considered at these meetings it is necessary for the manuscript and drawings for any illustrations to be in the hands of the Secretary fourteen days before the meeting of the Committee.

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*Series C* is issued prior to every General Meeting. It contains abstracts of exhibits to be shown and communications to be made, together with the titles of papers accepted for publication.

The annual subscription to *Series A. General Entomology* is £1 4s. od.; *Series B. Taxonomy*, £1 4s. od. (single parts 3s. od.); and *Series C. Journals of Meetings*, 6s. od.

As from January 1936 the journal *Stylops* is continued as *Proceedings Series B. Taxonomy*. Copies of volumes 1-4 are available at £1 16s. od. each, post free.



# MEETINGS

## TO BE HELD IN THE SOCIETY'S ROOMS

41, Queen's Gate, S.W.7

1938.

WEDNESDAY,	October	5	6.0 p.m.
"	"	19	8.0 p.m.
"	November	2	6.0 p.m.
"	"	16	8.0 p.m.
"	December	7	6.0 p.m.

1939.

WEDNESDAY,	January	18	8.0 p.m. (ANNUAL MEETING)
"	February	1	6.0 p.m.
"	March	1	8.0 p.m.
"	"	15	6.0 p.m.

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Fellows resident abroad, or otherwise unable to attend meetings, are reminded that notes or observations sent to the Secretary may be communicated to a General Meeting on their behalf.